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THE PROBLEMS OF THE NEBULAE.*

VINCENT FRANCIS.

Nebulae are celestial bodies whose history dates almost entirely from the advent of the telescope. In fact there was only one, the Great Nebula of Andromeda, that was known to Ancient astronomers, who saw only a faint patch of light scarcely visible to the average eye. But when Galileo turned his instrument on the constellation of Orion, he discovered that the middle star of the sword also appeared like a cloud (nebula being the Latin word for cloud), and from that time on more and more have been discovered as the size of the telescopes increased, until at present there are several thousand known and catalogued. The Herschels, father and son, contributed greatly to the number of known nebulae. When Sir William Herschel first started a survey of the heavens in the hope of discovering more of these objects, scarcely more than 100 nebulae and star clusters were known, and when, years later, Sir John Herschel compiled his famous catalogue, he was able to state the positions of several thousand, a very small fraction of which were not discovered by either his father or himself.

As the increased size of the instruments used made it possible to see more and more detail, a good many of the so-called nebulae were resolved into separate stars, which, with many additions, are known as star clusters. Therefore it was only natural to suppose that all the nebulae would eventually be resolved; so when, in the year 1864, Sir William Huggins turned his spectroscope on a nebula in the constellation Draco and found to his surprise and delight that it was composed, not of individual stars, but of glowing gas with no stars at all, it created a mild sensation in astronomical circles. But this discovery, great as it was, only served to put astronomers further from the solution of the

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problem than before, for it was soon found that comparatively few of the unresolvable nebulae were composed of glowing gas, and that the great majority showed spectra similar to the stars.

It was then seen that nebulae were not all alike, but were divided into different classes, those composed entirely of glowing gas, and those composed of solid particles. Of these, the gaseous are sometimes called the green nebulae, the Great Nebula of Orion being an example, and the solid the white nebulae, the Great Nebula of Andromeda representing this class. A great majority of the white nebulae and, in fact, a great majority of all the nebulae were found by Professor Keeler in 1899 to have a spiral form and they are called spiral nebulae. The rest of the white nebulae, of which there are but a few, are called planetary or ring nebulae; indeed the belief is held by some that these will eventually turn out to be spiral.

The spectra of nebulae, as stated before, are divided into two classes, solid and gaseous. As we all know, the solar spectrum is a continuous band of light running from the red at one end to the violet at the other. If considerable dispersion is used in forming the spectrum, countless very narrow dark lines will be seen crossing it throughout its entire length. It has been discovered that the spectra shown by metals and other substances heated to incandescence in the laboratory show lines, many groups of which are identical with those of the solar spectrum, thus revealing to us with a few small exceptions, the entire composition of the sun.

It has also been shown in the laboratory that glowing gases under low pressure show spectra just the negative of the continuous spectrum, i. e. the spectra are dark except where the lines cross, and these lines, instead of being dark, are bright. This class of spectrum is known as the bright line or flash spectrum.

Now when the spectra of nebulae were first taken, some were found to be continuous and others showed the bright line form, thus proving that the former were composed of solid particles and the latter of incandescent gas under low pressure.

In examining the spectra of a great number of stars, it has been found that the lines are not always in exactly the same position, but are slightly displaced, sometimes toward the red end and sometimes toward the violet, and in this way the radial motions or motions in the line of sight, and velocities of practically all the brighter stars have been found, displacement toward the red meaning that the star is receding from us, and toward the violet, approaching us.

On account of the spectrographical faintness of nebulae, it has been very difficult to obtain a satisfactory figure for the motions of any of them, as the lines in the spectra are too diffuse to detect any displace-

ment. During September, November and December, 1912, however, Dr. V. M. Slipher of the Lowell Observatory at Flagstaff, Arizona, using a specially constructed spectrograph, and making very long exposures on the Andromeda Nebula, found, taking the average of four plates, that this object was approaching the earth at the surprisingly high rate of 300 kilometers per second, this being the greatest celestial velocity hitherto observed. Since then Dr. Slipher has found certain nebulae with velocities of over 1000 kilometers a second.

On account of the diffuse appearance of nebulae it has been very difficult to obtain a parallax, not a single one showing the least signs of any. They are, therefore, conceded to be extremely remote from the solar system. Indeed no definite proper motion or motion at right angles to the line of sight, has been discovered for any of them.

In studying the location of the nebulae in the universe, it has been discovered that the farther away one gets from the Milky Way, the more numerous become the spiral nebulae, until a maximum is reached in the vicinity of the galactic poles. This, however, is not true of the other types, as they are practically all in or near the Milky Way.

In recent work by Professor A. E. Fath of Smith Observatory, Beloit, Wisconsin, he has calculated from 139 regions photographed, each a little less than two square degrees in area, that the average number of nebulae visible in the largest telescopes for each such area is 7.4, and that, as it would take nearly 22,000 such regions to cover the entire heavens, the number visible on photographs taken by the largest instruments, would be about 162,000. Incidentally, in the above mentioned 139 regions, 864 new nebulae were discovered.

Of the well known nebulae, two stand out far and away above the rest, the Great Nebula of Orion and the Great Nebula of Andromeda. The Great Nebula of Orion, although known from remote antiquity as a star of about the fourth magnitude in the sword of Orion, was not really discovered as a nebula until Galileo turned his famous telescope upon it. It is by far the greatest in the heavens, the central part covering an area larger than that of the full moon, and the outer extensions reaching several degrees in length. As stated before, this nebula, as well as all the others, is at an enormous distance from the sun, so great, some astronomers think, that the sun, together with his nearest neighbor in space, Alpha Centauri, would be deeply engulfed in the central condensation, less than a degree in area, and that its tentacles would even reach to the Pole Star, a distance of 44 light years.

If this great object were anything like as dense even as our atmosphere, its enormous weight would perturb the entire universe and its effects would be felt at the remotest confines. As nothing like such a

condition exists, it must be infinitely less dense than any vacuum that can be made on earth to cover this enormous area.

The question has been raised as to how a gas so inconceivably diffuse as this and exposed to the absolute cold of interstellar space, (more than 400 degrees below zero, Fahrenheit) can be self luminous. It has been shown in the laboratory that "a small quantity of hydrogen can be enclosed in a tube and excited by an electric discharge so that it emits light of the same kind as that which comes to us from the hydrogen in a nebula." It is not possible, however, that the conditions existing with the hydrogen in the tube and those existing in the nebulae even remotely resemble each other, but this is the best attempt that has been made at solving the problem.

Second to none but the Great Nebula of Orion is the Great Nebula of Andromeda. This, unlike the former, is of the white type, and has lately been shown to be spiral in form. As proved by its spectrum, this nebula must be made up of solid particles, but as rifts appear throughout it, such a great body as this must be made up of excessively minute and very diffuse dust particles, otherwise it would be as opaque as a wall and would be of such enormous weight as to disturb the whole universe.

As stated before, this nebula was known to the ancients as a hazy patch in the sky, but was always a puzzle until the increasing power of telescopes and the advent of the spectroscope showed it in its true light.

With the advent of high power telescopes, and more recently photography, into the study of the heavens, not only were the hazy stars found to be star clusters and nebulae, but whole regions of the sky, which apparently were just as clear and in which the stars shone just as sharply, were found to be more or less covered with nebulous matter. Thus it was found that practically the whole constellation of Orion was "a region affected with nebulosity," to quote Sir William Herschel. Also the Pleiades appeared covered with nebulosity on photographs of very long exposure.

It is also thought that regions like those just mentioned are covered with invisible or dark nebulae, as in certain sections mostly in the Milky Way, the light appears to be cut off or as if some absorbing medium intervened. There is one particularly striking example in the constellation of Sagittarius which "appears as a small oval patch about one-half the apparent diameter of the moon, in the middle of a dense star-cloud. Instead of looking sharply black like other portions of the sky, this spot seems dull, and at times a faint luminosity has been thought to be present, thus indicating an absorbing medium. The one or two small stars appearing in this dark space are thought to be this side of it.

In connection with the absorption of light in space, experiments are now partly completed which tend to show that the spectra of very remote stars show a marked absorption in the violet end compared with stars of the same spectral type, but known by determinations of parallax to be comparatively near us, thus making the former appear redder just as the sun looks redder when setting than at noon, owing to the greater extent of atmosphere through which we see it when near the horizon with the consequent absorption of the blue and violet light.

Speaking of dark nebulae, it is now thought that the nebulosity surrounding the stars in the Pleiades is really dark and shines by light reflected from the stars of this cluster, as the spectra of both appear to be identical.

Another proof of the existence of dark nebulae is the nebula surrounding Nova Persei, "the new star of the new century." This extraordinary star was discovered in February, 1901. In a few days it increased in brightness from invisibility to the brightest star in the northern hemisphere. After reaching its maximum brightness on February 24, it began to wane slowly and irregularly until in August it was of only the sixth or seventh magnitude and invisible to the naked eye. On September 20, Professor G. W. Ritchey of the Yerkes Observatory in Chicago photographed the star with an exposure of four hours. Early in September there had been no trace of nebulosity surrounding it, even when observed through the 40″ telescope of the same observatory, but on this photograph there appeared two wisps extending toward the west and curving toward the north and looking like the faint traces of a spiral nebula. In November, not only a well formed spiral was seen, but the nebula had increased in size at the alarming rate of eleven minutes of arc in a year.

It was impossible to believe that matter from the star had traveled at such a rate from it no matter how great the force behind it, so the natural solution of the problem was to suppose that a dark sun had run into a dark nebula, the intense heat caused by the contact making the star blaze forth in all its splendor, and then, as its light traveled from the source, it illuminated the nebula, causing it to shine by reflected light.

As the light advanced at the rate of eleven minutes of arc a year, as stated before, the distance at which this object must be is at least 300 light years, that is to say that the catastrophe occurred and its light started toward us at the rate of 186,000 miles a second, at about the time that Galileo first pointed his telescope at the heavens, and that in seven months time, it was lighted up in all directions so that its length and breadth would each be equal to about one third the distance from the sun to his nearest neighbor, Alpha Centauri.

There have been several theories advanced as to what part the nebulae play in the formation of suns, planets, or groups of stars, the most famous being the Nebular Hypothesis originated by the great French mathematician and astronomer Laplace.

This theory takes our own solar system as an example. It commences with the idea that the matter which formed the sun after the initial catastrophe was spread out like a disc or round nebula and reaching to the farthest limits of the solar system, presumably at that time to the orbit of Uranus, Neptune having not yet been discovered. At this stage it was perfectly stationary, not revolving on its own axis, but the gravitation of all its particles toward the center caused it to shrink, this creating crowding and collisions which caused it to revolve ever so slowly at first.

As the density became greater and greater, the revolution became faster and faster until a time came when the centrifugal force became so great that a ring was thrown off. When the mass had contracted still further, another ring left the sun, and then another and another until a ring had been left to form each planet.

Collisions among the particles forming the rings caused knots or bunches to be formed, these knots reaching after a time such a size that the rings broke up into several condensations, the condensations of each ring revolving in approximately the same orbit. Finally the attraction of these condensations for one another and the slight differences in their periods of revolution, caused them to come together, and thus we have our eight planets (at that time seven) from eight rings left by the sun at the time its diameter equalled the diameter of the different planets' orbits. In the case of the asteroids, it was supposed that the ring from which a planet would have been formed at this distance from the sun, after breaking up, was not allowed to come together into one body owing to the perturbing action of the giant planet Jupiter, and that its particles, only a few at that time, must forever remain separate.

This theory was advanced nearly a hundred years ago, and since then it has been given up by most, if not all astronomers, they for the most part thinking that while it might hold good for one particular case, it would be totally inadequate to meet the vastly larger and more difficult problems of the present day. The only objects which could in any way support this hypothesis are a few planetary and ring nebulae which appear like a ring with a central star, and the rings of the planet Saturn. However, when the Nebular Hypothesis was first put before the public, it was considered a great advance toward the solution of the problem, and Laplace deserves the greatest credit for formulating it, as nothing at all acceptible had as yet been thought of.

Another theory which has recently been evolved and which has gained a good deal of credence among astronomers is the Planetesimal Hypothesis of Professors Chamberlin and Moulton. This theory applies to spiral nebulae only. It supposes that two independent suns possibly bright or possibly molten, or gaseous at the core but with a more or less thick crust on the surface, approach very close to each other. This causes great tidal pressure on each in the line of gravitational pull, making each tend to take an ellipsoidal figure. If the crusts are very thin or there are none at all, they will assume this shape comparatively easily, but if the crusts are more or less thick, they will cause great resistance, and when the strain becomes too great on the weaker one, it will explode with great violence, "and the internal mass will leap out on the two opposite sides in great fiery spouts." These spouts, owing to the rotation of the body, will take the form of spirals and enormous amounts of matter will be scattered far and wide, what is left, after the body able to withstand the strain has gone on its way, forming the nucleus of the newly formed nebula. The matter thus thrust forth from this nucleus condenses and "finally turns into streams of solid particles circling in elliptical paths about their parent sun," these particles being the planetesimals of the theory.

As these planetesimals revolve, collisions occur, condensations are formed, grow larger, and finally form the planets.

This theory does not prove entirely satisfactory, as most of the spiral nebulae are so enormous that instead of forming planets they are undoubtedly forming mighty streams of countless suns, and that instead of the two original suns separating, if they approached close enough to each other to cause such enormous tidal outbursts, their mutual attraction, if they were anywhere near equal in size, would hold them together so tightly, that they could never again break away.

Another theory takes for its chief arguments the repulsive power of light on minute particles, or radiation, and the great majority of nebulae that are clustered about the poles of the Milky Way. It says that when suns are formed from the nebulae in this neighborhood, they are drawn by gravity toward the Milky Way on account of the vast majority of the matter of the universe in this body. The nearer they get to it, the more light they receive, thus, according to the theory of radiation, forcing minute particles away which immediately start again for the galactic poles, there to come together to form new nebulae from which new suns are made to begin their journey again.

If this theory is correct, an endless chain is constantly in process, and the life of the universe is infinite and unending.

Another theory that has lately been advanced states that rapidly rotating spirals tend to become circular, the universe being in an

advanced stage of this process, having turned from a spiral into a more or less flattened circular disc bounded by the Milky Way, and that the vast number of spiral nebulae that we see are all separate universes undergoing the same transformation.

Most of the problems concerning the nebulae that the present day astronomers have before them are presented here, and as each new discovery opens up new fields, the more that one knows about these strange and wonderful objects, the more difficult becomes the problem of how they were formed, what part they play in the universe, if indeed they be in this universe, and what they will become in the almost infinite future.

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THE LUNAR CRATER LINNÉ.

JOHN A. COOK.

In Popular Astronomy for March 1913, I reported having observed a small crescent shaped elevation in the white spot out on the floor of Serenitatis, well known by the name of Linné.

All students of our satellite are aware that this object has been more attentively observed than any other spot on the Moon's surface, as it has been believed that Linné offers better opportunities than any other region to prove that our beautiful satellite is not dead and cold to the center.

Neison, in his great work, 'The Moon', devotes several pages to this little, apparently insignificant object. W. H. Pickering in his, 'The Moon', sums up the situation far more briefly, as follows: Riccioli, in 1651 shows it as a deep crater. Schröter, in 1788, describes it as a round bright spot, with an uncertain depression. Lohrmann early in the last century, describes it as a deep crater, and more than four miles in diameter. Mädler made it six miles. Schmidt drew it eight times, and made it seven miles, in diameter and one thousand feet deep. In 1866, it disappeared for a time; after a few months it reappeared as a very small crater not more than a quarter of a mile in diameter. It increased in size until it measured one and a half mile, then it decreased until it was only three quarters of a mile, according to Professor Pickering, 'The Moon', page 39.

My observation mentioned above, when I first saw the crescent shaped elevation, was made on March 7, 1911. It was verified in other observations as to the elevation, but I never saw the crescent again.

On May 8 and July 6, 1916, observations were made under very favorable atmospheric conditions. The elevation was easy with power of 200 on the 7″ refractor. It has lost its crescent shape, is larger than when last seen, and is now a typical little mountain, like Pico, except in size. It throws a shadow larger than that in any of the small craters in the vicinity with which it may be compared.

We have it on good authority, that the white spot varies in size, being larger at sunrise than when the sun has been shining down on it for a week or ten days. This has been accounted for by Mr. Pickering, as vapor issuing from an orifice; on coming into the colder outer temperatures it is deposited as hoar frost, and partly disappears under the sun's heat. If this is true, and it is very plausible, the little mountain we have seen form is in all probability ice, rather than more durable rock, and further change may be expected. The case offers an opportunity for the world to settle the long drawn out controversy, as to whether there is any change taking place on the surface of our Satellite, other than can be accounted for by the sun's heat, which many deny.

The observation requires favorable conditions, and can only be made with any hope of success under extremely oblique light, as the elevation disappears when the white spot appears; this sometimes happens in an hour and sometimes not during the same night. The writer has watched the first rays of the sun strike the little mountain, and seen the familiar spark of light, when the surrounding sea floor was yet in the shadow, the terminator not having reached it. The elevation is not in the center of the white spot.

I have not been able to catch conditions favorable at the hour of sunset, and if there is any crater within the white spot, it is concealed by the shadow seen under the rising sun.

Macon, Mo.

CHRONOLOGY OF THE EGYPTIAN PYRAMIDS.

F. J. B. CORDEIRO.

These monuments of remote antiquity have engaged the curiosity of man from time immemorial. A host of travelers, Greek, Roman, mediæval Arabian, and modern, have examined them, measured them, pondered over them and left us their opinions. When were they built, what was their purpose, and what hidden meaning do they contain? We know very little more of these things than Herodotus did. He recognized, as we today know, that they were the tombs of great personages—ancient rulers,—but beyond that we cannot go with any certainty.

The bibliography since 1799, the year that the scholars attached to Napoleon's army of invasion founded their Egyptian Institute, is enormous. Among many of these writers the pyramids have exercised a peculiar influence, in that it has led them to form scientific or religious theories which they sought to justify through them, or has led them to attempt to fit preconceived theories to what they found there. This influence has not only left its mark upon the genus "Crank", as was to be expected, but has also attacked some of the most conservative men of science.

In 1840, an individual known as Mr. John Taylor, of Gower St. London, founded a religious sect known as the "Pyramidists," their religion being directly revealed in the Great Pyramid. There is nothing very remarkable in this, but it is remarkable that twenty years afterwards Professor Piazzi Smyth in Scotland, and the Abbé Moigno in France, became the chief prophets of this new religion. Now both of these gentlemen were conservative scientific men, logical by nature, of excellent general judgment, and trained in the strict methods of the mathematico-physical sciences. Professor Smyth was for many years Astronomer-Royal of Scotland, and a most competent and distinguished astronomer. The Abbé Moigno was the scientific associate of Leverrier and well known to mathematicians by his work. According to these gentlemen, the exact measures of all the constants of the solar system are contained in the Great Pyramid. A more exact value of the distance of the sun from the earth can be found in the Great Pyramid, than by the most refined observations and calculations, by reason of the fact that the builders put it there by "divine inspiration." The length of the polar axis, the precessional period, the sidereal day, the year, and in fact all measures are accurately recorded there.

Professor R. A. Proctor took the pains to demolish these contentions one by one, which he did most successfully and with evident delight. There have been few clearer minds than his, and it would seem unlikely that one who so readily detected a flaw in another's argument would permit an error to enter into his own. And yet it would seem that this fatal pyramid influence did not leave Professor Proctor unscathed. After saying that "It is almost impossible to mark any limits to what may be regarded as evidence of design by a coincidence-hunter," and quoting from De Morgan's "Budget of Paradoxes," he goes on to *prove* that it was the design of the builders of the Great Pyramid to place the centre of its base exactly on the thirtieth parallel of latitude. True, it is not there, but about one and one-half miles to the south of this parallel. But he adds, the reason is that they knew nothing of atmospheric refraction. Further, according to Professor Proctor, this error shows that these ancient astronomers must have used the northern stars in determining their latitude, and not the sun.

Now there are some thirty-eight other pyramids within twenty miles of the Great Pyramid on the left bank of the Nile, varying in latitude from 29° 17′ to 30° 4′. In the immediate vicinity of the Great Pyramid and *near* the Nile, there is no spot where it would be possible to raise such a structure exactly on the thirtieth parallel. For the Great Pyramid is on the extreme northern verge of the old lime stone reef which was washed by the ancient Mediterranean prior to the formation of the Nile delta. If the builders had attempted placing it farther north, and anywhere near the river, they would have to have dug through an interminable amount of Nile silt before finding bed rock.

It is evident that the first consideration was to find a suitable rock surface which could be planed down to form a platform. The particular latitude of such a platform did not matter, as is clear from the other pyramids.

The orientation of these pyramids, which all have their bases very exactly in the cardinal directions, could only have been determined by astronomical observations, and the builders were undoubtedly astronomers of a high order. We may grant much, but it seems to be unnecessary to grant more than is called for. They understood goniometry perfectly and probably could measure their angles within one minute. They could determine latitudes quite accurately, but that they knew that the earth was a globe and what its diameter is, as Professor Proctor maintains, seems doubtful. As they knew nothing of theoretical mechanics, they could not have known that the earth is compressed, and they could not have calculated the return of comets, as Diodorus Siculus credits them with having done. They probably knew nothing of the Precession of the Equinoxes, although it is barely

possible that they might have detected this through careful and long-recorded observations, just as thousands of years later Hipparchus detected it. They undoubtedly knew very accurately—within one minute—the inclination of the earth's equator to the ecliptic, or the breadth of their torrid zone.

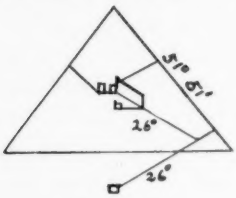


Fig. 1

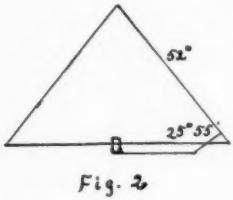


Fig. 2

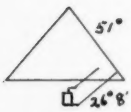


Fig. 3

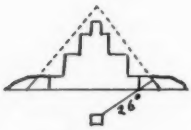


Fig. 4

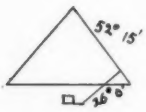


Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

PYRAMIDS AROUND GIZEH.
Meridional Sections
Fig. 1 Khufu (Cheops)
Fig. 2 Cephren
Fig. 3 Menkaura

It is astonishing that all coincidences, analogies and theories have heretofore been taken solely from linear measures of the Great Pyramid, while no attention has been paid to the angles. In 1638, Professor Greaves, then professor of astronomy at Oxford and Astronomer-Royal of England, visited the Great Pyramid and made some careful measurements. He gave the inclination of the entrance passage as 26°. Angles did not enter into Professor Piazzi Smyth's scheme and all that he has to say about them is, "The angle of the rise of the Pyramid's flanks and the angle of descent and ascent of its passages are both peculiar angles, characteristic of the Great Pyramid." Professor Smyth gives the

inclination of the faces of the pyramid as 51° 51′, and the inclination of the descending and ascending passages as exactly alike, and 26°. These angles are not only characteristic of the Great Pyramid, as he says, but are characteristic of all the other pyramids. The only suggestion that Professor Smyth has to make in regard to this particular angle is that, provided the builders divided their circle into 1000 parts, then "The angles 26° and 52° would be, after a fashion, commensurable parts of a whole circle." The trouble is, they are not. Since at various times, before or after, there was probably a connection between the Egyptian and Babylonian astronomers, it seems likely that they divided their circle into 360 parts, but we have no knowledge on this point.

A writer in the Encyclopedia Brittanica has suggested that this particular angle was chosen because its tangent is one-half, i.e. the rise is exactly one-half of the advance. But the angle whose tangent is one-half is 26° 34′, and this is an angle which the pyramid builders could not possibly have confounded with their own peculiar angle.

The most reliable angle measurements that we have of the first nine pyramids around Gizeh, are as follows:

		Slope		Passages	
		°	′	°	′
1	Khufu (Cheops)	51	51	26	
2	Cephren	52		25	55
3	Menkaura	51		26	2
4			—	26	
5		52	15	26	
6			—	26	
7		52	10	26	
8		52	10	26	
9		52	10	26	

These angles, while in each individual case only approximate, give us as average values 26° and its double 52°. The sixth, seventh, eighth and ninth pyramids have crumbled down into ruinous heaps, and are probably older than the others.

Now there can be no doubt as to the reality of this pyramid angle. It is a particular and carefully selected angle, and it "sticks out" everywhere. The question naturally arises—why this particular angle, when there were so many other angles that might just as well and just as easily have been chosen? Before answering this question, let us be sure that we are not overborne by the "Pyramid Influence" which can carry away not only the plain "Crank," but an Astronomer-Royal and a genius like Professor Proctor. Let us not merely hunt for coincidences and then build up theories upon them. There are coincidences, and coincidences, and it is the province of the theory of probabilities to sift such cases.

In the first place the angles are everywhere the same, but these are not coincidences. The agreement was planned; it was not accidental. Was there any angle which would be likely to impress itself upon them and lead them to adopt it for their pyramids, as their sacred angle? Yes. There was then, and there still is, one angle and only one angle in all nature which presents itself unmistakably to mankind. This angle is the inclination of the equator to the ecliptic, or the breadth of the tropical zone. The ancient Egyptian astronomers certainly knew this angle to a minute. We need not suppose that they had any idea of the revolution of the earth about the sun, or the real reason for this seasonal wandering of the sun, for they probably had not; they simply knew the angle because they had measured it, and quite accurately at that. If two men, wholly independently of each other, are to come to me and utter some word, the chances that those words shall be the same are infinitesimal. But if they should utter the same word, out of all the possible words they might have chosen, then it approaches a certainty that there was collusion. Such a coincidence savors of conscious mental effort.

But, it may be said, the tropical angle—the angle between the equator and the ecliptic—is only 23° 27′. That is the present angle, but was it the angle at the time the pyramids were built? Decidedly not. The angle at *that* time was in all probability around 26°.

Less than 400 years ago, the general belief was that the earth did not move at all; it was supposed to be absolutely stationary. Finally the evidence became overwhelming that it must have at least two motions —a rotation and a revolution about the sun. For this view to become accepted it was necessary for the scientific men of the day to be *willing* to examine and weigh the evidence. This was for a long time an impossibility. In the next place it was necessary that they should be *able* to *understand* the nature of the question, but though the mentality required here is very moderate, there were further difficulties. Two hundred years ago, Bradley rediscovered the Precession of the Equinoxes by observation just as Hipparchus had originally discovered it, 120 B. C., and Newton gave the reason for it. This was ignored for a long time, but finally accepted, rather upon authority than from any distinct understanding of the cause. There is still another motion of the earth which theory shows must exist, and which does exist. This is due to the elasticity of the earth and consists of a slow pendulation of the axis of the earth through the pole of the ecliptic. The earth's axis describes a small precessional circle about the pole of the ecliptic, and if the earth were *absolutely* rigid, these circles would be closed curves and the inclination would remain forever practically unchanged. But the earth is not absolutely rigid, with the result that the preces-

sional circlings are not closed curves, but spiral gradually inward. In a very long time, therefore, the inclination of the earth's axis undergoes very considerable changes. The reader who wishes to inquire further into these motions is referred to Routh's "Rigid Dynamics," "The Gyroscope" (Spon and Chamberlain), and an article in "POPULAR ASTRONOMY," August 1915. Our data as to various inclinations of the earth's axis in the past are necessarily scant and not very reliable. Perhaps the best value we have is that of Erostosthenes (236 B. C.) who found it between 23° 52′ and 23° 51′. Hipparchus (120 B. C.) is said to have found it 23° 51′.

Taking this value, it will be necessary to go back to about 10,000 B. C. before the inclination is 26°. Using Ptolemy's (130 A. D.) determination, which is in all probability erroneous, the date would be 6370 B. C. The estimates of the time of the pyramids vary widely—all the way from 3000 B. C. to 13,000 B. C., and even more. The simple fact is, we do not know when they were built.

If, however, the angle 26° represents the natural angle at the time they were built, then we have some definite land marks in our chronology. In that case we have a permanent record of the inclination of the earth's axis at some time in remote antiquity, and knowing the rate we might find the time, and vice versa.

It is, of course, possible that the angle 26° marks only the era when pyramids first began to be built, and that afterwards this angle was slavishly and religiously copied. In this case, the angle would lose its value as a chronological factor. But it seems more probable that the builders who were able to determine the angle were also able to revise, and did revise it, from time to time. Possibly the slightly greater angle in the older pyramids—seventh to ninth—points to a greater age by some six to seven hundred years.

The pyramid builders selected a peculiar angle—in the neighborhood of 26°, and its double 52°—which they put into all their structures. They were astronomers and geometers of a high order, as their mathematical structures prove. That they should have selected as their standard pyramid angle, the breadth of their then tropical zone, seems natural, as it was and still is, the only definite angle presenting itself in nature. It is practically certain that the inclination of the earth's axis had this value about 10,000 B. C. There is a strong presumption, therefore, that the pyramid angle represents the great angle of nature. With less certainty, we can infer that the pyramids were built some time between 11,000 B. C. and 6000 B. C.

THE MOTION OF THE POLE.

O. H. TRUMAN.

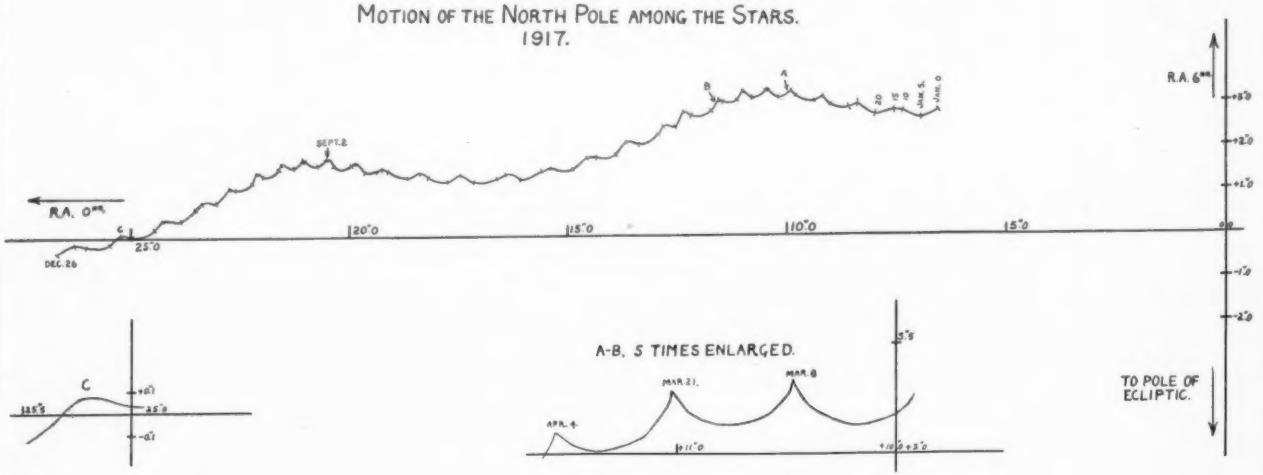
All text books on astronomy give a description of the phenomona of precession and nutation, but never have I seen the last represented by a proper figure—a figure which shows what actually happens instead of an idealized version, and is calculated to give the student a correct and definite idea of it. In an endeavor to present the subject in a more correct and at the same time a more appealing way than common, therefore, I have made for our University a lantern slide from the accompanying drawing, which will be used in conjunction with another slide showing the conventional representation of the precessional circle among the stars. An illustration of the latter is to be found in many astronomical works, for instance, in Young's Manual of Astronomy, p. 146, and is doubtless familiar or accessible to the reader.

The large circle on that drawing represents the 25,000 year path of the pole of the equator about the pole of the ecliptic, and this path would be exactly followed, at a uniform rate, if the force were uniform which tends to tip the earth's axis so as to make the equator coincide with the ecliptic.

Now it is well known that this force is due to the attraction of the sun and moon on the equatorial bulge of the earth, and if the sun and moon were always in the same positions with respect to the earth, and always the same distance from it, we should in fact have a constant force and a uniform precession.

But this is not the case. Twice each year the sun is on the equator, and its tipping force upon the earth is reduced to zero; twice each month the same is true of the moon. Moreover, once every nineteen years the plane of the moon's orbit is at a maximum inclination to the plane of the equator, the average distance of the moon from that plane is great, and its tipping effect correspondingly increased, while at intermediate intervals, because of the revolution of the moon's nodes, the reverse is true. And added to all of this, the distances of the moon and sun from us vary by important amounts.

So the twisting force upon the earth is very irregular, and the pole, instead of moving at a uniform rate along the precessional circle, moves at a variable speed, and departs a little from the circle, sometimes toward, sometimes away from, the center. When the whole matter is submitted to analysis, it turns out that, something as we avoid the irregular motion of the sun in time-keeping by the device of an imagin-


MOTION OF THE NORTH POLE AMONG THE STARS.
1917.
R.A. 0ʰ
R.A. 6ʰ
SEPT. 2
DEC. 26
25″0
120°0
115°0
110°0
105°0
A
B
C
A-B. 5 TIMES ENLARGED.
MAR. 21.
MAR. 8
APR. 4.
TO POLE OF ECLIPTIC.

ary sun thought of as moving uniformly along the equator, so here we can think of a mean pole moving exactly along the circle at the average rate of the true pole, and find the place of the latter by applying small corrections to the place of the former. The motion of the mean pole is what is commonly spoken of as precession; the motion of the true pole with respect to the mean pole is nutation.

It is possible to compute the nutation by means of the Besselian star numbers in the *Nautical Almanac*. I have done this for intervals of five days thrughout the year 1917, and plotted the results in the largest of the annexed drawings. The X axis, 25″ or more long, is a very small section of the circular path of the mean pole; and, of course, being a very small section of a circle, it looks like a straight line. The intersection of the two axes, 0.0, is the point occupied by the mean pole at the beginning of the year, January 0.217 da., and the curve shows the motion of the real pole and its position for various dates. When the curve is above the axis, as it is for most of its length, the pole is outside the precessional circle. The marks across the curve are at five day intervals.

The first thing to be noticed is that the curve descends, on the whole, throughout the year. This is the effect of the long nineteen year irregularity due to the motion of the moon's nodes. The pole has been outside the circle for nine and a half years, at most by nearly 10″.0, and is just crossing the circle to go the same distance inside. The pole, moreover, is far ahead of its mean place, but at the end of the year will commence to fall back, and in four and three-fourths years will be overtaken by the mean pole. Thereafter it will remain behind the latter for nine and one-half years, then come ahead of it again, and so on.

Next there is apparent another fluctuation, coming to maxima about March 8 and September 2, times half a year apart. This is due to the sun finding itself furthest from the equator, and so able to exert the most force, twice a year, and upon the equator, and so powerless, twice.

Then there is a still smaller variation, with a period of a month, for the moon suffers fluctuations in its power the same as the sun, and for similar reasons, only twelve times as rapidly. The variations due to the changing distances of the sun and moon from us are too small to be noticeable in the drawing.

Last of all, the great irregularity of motion along the curve is to be noted, for while the pole usually makes good progress, sometimes during an interval of five days it scarcely moves at all.

In order to show the different character of the curve at different times, I have drawn two small portions of it, each enlarged five fold. During March it has little sharply pointed peaks, but by the end of the

year these are rounded off, as at C. I did not, of course, attempt to show the form of the main curve with such minuteness.

Had there been any stars near the pole's path I should have marked them, but none, even as faint as seventeenth magnitude, are close enough to show. But after all this is not surprising, for if one should put on his telescope an eyepiece having a field less than half a minute in diameter, and point at random on the sky, what would be his chance of seeing a star? The entire year's path of the pole is comprised in a space but little larger than the trapezium of Orion, and the minuter variations which I have drawn are so small that if traced upon the sky they could scarcely be seen, even with the greatest telescopes. But from the eye of mathematics they do not escape. It sees them and predicts their coming years into the future, and determines the allowance that must be made for them in those minuter observations where alone they are able to make their presence felt.

University of Iowa.

Sept. 29, 1916.

POLARIS.

CHARLES NEVERS HOLMES.

Where Cepheus reigns weakly in the sky
And Draco yawns with widely open jaws,
Where Ursa Major circles low and high
Propelled by power of celestial laws;
Where Ursa Minor daily, nightly, turns
Around a sky-set axis of man's Home,
Polaris like supernal beacon burns,
A pivot-gem amid our star-lit Dome.

Amid the darkness, the silence of evening a star-gazer stands shadowless beneath suns almost incomparable in their remoteness. No cloud, no moon, no planet shining brightly. No electric light, no lamp in a window, no sudden gleaming ray as some automobile passes swiftly. Darkness on all sides, darkness everywhere except far, far overhead, in the firmament sparkling with jewels of fire. Underfoot the winter's snow, almost invisible beneath night's shroud; spotless snow as yet scarcely trodden by man. A frigid night, so dry and stimulating that the cold is hardly felt; and there are health and vigor in each indrawn breath. Many miles from the glare and glitter of a large city, yet not far from homes hidden by knolls and woods. Quiet

almost as a tomb, silent almost as in some aeroplane floating in space. Not even the warning bark of a dog from a distance, a condition of perfect terrestrial peace and tranquility. And overhead the stars!

From earthly darkness to celestial light, from silence and solitude to sun and satellite expressing titanic energy and sidereal association. An ensemble of firmamental splendor that presses upon a star-gazer as softly as some spider's web and yet as stupendously as an overhanging avalanche. Safe indeed feels a student of astronomy, surveying calmly with his small or large telescope the myriad suns framed by the Milky Way. Safe indeed!—amid the architecture of a Builder whose invisible laws are perfect, whose Hand holds like some gigantic vise the fiery star or the shining satellite. Safe in the midst of moving planets which are revolving rapidly like so many ponderous wheels in the illimitable factory of a universe. Atomic man, groping blindly afar from his terrestrial home, accumulating bit by bit astronomical knowledge more priceless than earthly jewel or gold. And presently, slowly, this shining ensemble of the firmament seems to fade before the eyes of a star-gazer amid a wilderness of snow, where all is dark and silent, and he gazes long and earnestly upon one sun, an inconspicuous sun, twinkling quietly to the northward.

It is Polaris—Polaris of Ursa Minor—Alpha Ursae Minoris! Truly it is not a conspicuous star, particularly when winter's glorious galaxy sparkles so splendidly in the south. *There* are Capella, Aldebaran, Rigel, and—most spectacular of all—brilliant Sirius. Certainly Polaris appears very, very insignificant when contrasted with any of these first-magnitude sky-gems, and to those of us inexperienced in astronomical science this chief sun of the constellation Ursa Minor seems hardly worth more than a momentary glance. But to those who are experienced in sidereal research, and indeed to anyone who remembers what he has read about the North Star, this inconspicuous sun is of great importance, despite its inferior appearance. Indeed, most of us have heard or read something concerning Polaris, and some of us have tried more or less successfully to discover its whereabouts. Not a few otherwise well-informed individuals are in doubt respecting the exact position of Alpha of the Lesser Bear, although they are very certain that the Dipper has something to do with finding its position. And it is true that some of us after discovering the Dipper and even its "pointers" are still unable without assistance to see the North Star. So unaccustomed are they to the starry skies, where almost every sun looks alike to them, that ofttimes an experienced star-student has some difficulty in "showing" Polaris to an inexperienced star-gazer who will perhaps not believe at first that such a small, twinkling firmamental object is really the famous North Star.

But an experienced sky-student standing beneath cloudless, moonless, darkened heavens, will not have the slightest trouble in finding Polaris. It is the time of night and of year when the Dipper must be in the northeast, and *there* it is! Anyone can soon find the Dipper's curving "handle", the end star of which is named "Benetnasch", and, following that handle from Benetnasch through to the other end of the Dipper, we pass in all seven stars; Benetnasch, Mizar, Alioth, Megrez, Phecda, Merak and Dubhe. Now, Merak and Dubhe, the two suns farthest from Benetnasch, are the famous, so-called "pointers", and an imaginary line drawn from Merak to Dubhe and extended northwestward, or whatever direction the Dipper's location requires, will come near the North Star. The "pointers" do not aim directly at Polaris, and that sun is a little way firmamentally from Dubhe; but the North-Star is the most noticeable sun which the imaginary line first passes, and even an inexperienced sky-student should not have great difficulty in finding Polaris if he "sights" accurately from Merak and Dubhe.

The constellation of Ursa Minor! The so-called Dipper forms part of the constellation Ursa Major, the Greater Bear, and Ursa Minor reminds us somewhat of a smaller Dipper. It is, however, a poor, dim imitation of the Great Dipper, as well as an equally poor imitation of a sky-bear, Nevertheless, we have been accustomed for many centuries to call it the "Lesser Bear" and perhaps that name is as suited to it as any other. There are, as in the case of the Great Dipper, seven suns in the Small Dipper; Polaris being the end star in its handle and the other stars being in respective succession, Delta, Epsilon, Zeta, Eta, Gamma and Beta. Of course, the North Star is Ursa Minor's most noticeable sky-gem but Gamma and Beta are also rather noticeable, being often called the "Guardians of the Pole." In a way Gamma and Beta of Ursa Minor resemble Beta and Alpha of Ursa Major for these first two suns point rather indefinitely during evenings of January in the direction of incomparable Sirius and also towards blue Vega. But although Gamma and Kochab of the Lesser Bear attract somewhat the attention of star-gazers by their twin-like appearance close to the inconspicuous constellation of Draco, the constellation Ursa Minor would be in the same neglected class as Draco, the Dragon, were it not for the sun twinkling at the very end of its handle—Polaris the North Star.

Polaris is called the "Pole Star" yet it is not exactly at the Pole. At this point a few words should be inserted in explanation of the term "Pole". There are, of course, two of these celestial Poles, northern and southern; but we speak usually of our own northern Sky-Pole merely as the Pole, since the southern Sky-Pole's position—a position not marked by any noticeable star like Polaris—cannot be seen by us in

these latitudes. Now naturally we think of the Pole as something up north, some point on our Earth's surface which so many brave men have died in trying to reach. That is what is known as the north geographical pole; but it is not the northern Sky-Pole. This north Celestial Pole is a stationary, invisible point in the heavens, just as many degrees below the zenith as is our latitude below the terrestrial north pole. In other words, were we exactly at the north geographical pole, this northern Sky-Pole would be precisely overhead. That is, just as though the Earth's axis, emerging from the top of our Planet, should continue into the immensity of outside space until it reaches Polaris. At present we are fortunate in having a typical second magnitude sun to mark the approximate position of our Celestial Pole. As we leave the north terrestrial pole, however, and descend towards the equator, the apparent firmamental place of Polaris changes from the zenith until at the equator Polaris would twinkle on the horizon. But Polaris has not altered in the least degree its position; our own place on the Earth's surface relative to the North Star has changed since we left the terrestrial north pole of snow and ice. The North Star's northern Sky-Pole is fixed and stationary exactly as the north Earth-Pole is stationary; the rest of our earth rotating around this terrestrial pole or axis. Thus, Polaris, our own northern Pole Star, should remain apparently motionless; but such is not quite the case for Polaris is not precisely at the Sky-Pole, being about 1-1/6 degrees away from it, and, as a result, our North Star makes a constant, small revolution around and around the Celestial Pole.

But Polaris is so near the Sky-Pole that it serves as a veritable signpost towards the north. Of course if the sky happens to be overcast, this North Star would be of no value; but once seen the pilot would instantly know in which direction to steer his ship. The discovery of the compass was of greatest importance to ocean navigation, particularly on cloudy or stormy days; but whereas the magnetic waves controlling the compass are somewhat changeable, our North Star is faithful, apparently motionless in the north, occupying from year to year practically the same relative position. But even Polaris is slowly changing in its firmamental position or rather we are slowly changing from Polaris. Our terrestrial axis has a certain circular movement called precession which causes, of course, an apparent, gradual alteration in the sky-position of suns and constellations. As a result, our Celestial Pole is rotating in a kind of firmamental circle, being at present within 1-1/6 degrees of Polaris, and some 12,000 years hence it will be not far from the blue, brilliant sun Vega. So that we see in a few centuries our North Star will be no longer at the Sky-Pole, although so far as it concerns us of this generation Polaris will be our faithful North Star as long as we live.

It is interesting to relate the astronomical history of the precessional rotation of our Sky-Pole. Some 4600 years ago, about twenty-seven centuries before the beginning of the Christian Era, this circular movement of our axis caused the celestial pole to pass close by a star called Thuban, or Alpha Draconis, so that at that time all the other suns and the constellations of northern latitudes seemed to revolve around that star—Thuban was the Polaris of those days. Centuries elapsed, the north celestial pole continued its slow circle overhead, until tonight it is situated only 1-1/6 degrees from Alpha Ursae Minoris. In the centuries to come, it will leave Polaris and pass through the inconspicuous constellation Cepheus, being around 7500 A.D. not far from Alpha of Cepheus, which is at present not as noticeable a sun as Polaris. After departing from Cepheus, the Sky-Pole will approach Cygnus, coming near Delta of that constellation. About 14,000 A.D., the blue, brilliant sun Alpha of Lyra will become our pole star, although Vega's position will not be as conveniently close to our celestial pole as is Polaris of this twentieth century. Around 23,000 A.D. our northern terrestrial latitudes will have once more the present proximity of Thuban for their sky pole, and about 28,000 A. D. the celestial pole will be back again where it is tonight. In other words, it takes this pole some 26,000 years to complete its circuit, from Polaris to Polaris. But what firmamental, what terrestrial changes may occur in 260 centuries!

During this present twentieth century, however, Polaris of Ursa Minor is our North Star. Perhaps a more accurate term would be "our North Stars!" For Polaris is not a single sun, all alone in the darkened heavens. It is known as a binary star, that is, two stars sparkling so close together and associated so closely that our unassisted eyesight cannot separate them. When the telescope is turned upon such a binary star, it will be found to have a companion, which may revolve around it or both may revolve around their common center of gravity. The companion of what we know as Polaris is, of course, telescopic, being about of ninth magnitude (8.8); the brighter sun of Polaris being of about second magnitude (2.1). And, in addition, it has been discovered through the spectroscope that Polaris is a triple sun, a system of three stars, number 1 and number 2 revolving around a common center of gravity in 3-97/100 days, and also revolving around sun number 3 in about twelve years. However, we need not trouble ourselves with sun number 3; but limit ourselves to the range of our telescope. It has been said that the ninth magnitude companion can be seen with a three-inch glass, and even a telescope of a trifle less diameter might be sufficient, provided sky conditions were favorable. When, however, a star-gazer separates Polaris into its two telescopic suns, he will find that the

larger sun has a yellowish hue, while the smaller, which is very inconspicuous compared with the larger star, possesses a bluish tint.

Polaris, taken as a whole or as unit, is what we know as a second magnitude star, in fact it is almost a standard second magnitude star, just as ruddy Aldebaran is almost a standard first magnitude star. Of these second magnitude sky-gems there are about 48, including the famous "pointers" of Ursa Major. Star-gazers under clear, moonless skies, should compare the noticeable sparkle of Polaris (2.1) with the very brilliant scintillation of Sirius (—1.6). By comparison, Polaris is almost invisible. Yet we should remember that Sirius is one of the nearer suns (8.7 light years) while Polaris is estimated at about 70 light years, more or less. To get an adequate idea of the brilliance and volume of Polaris, it would be necessary to view this so-called second-magnitude star from the distance of Alpha Centauri—4.3 light years. There are other interesting facts about Alpha of the Lesser Bear, such as its "proper motion" across the firmament which is about 4/100 of a second of arc per year, and its radial progress towards our earth (16 miles per second in 1889), a velocity which had decreased about one-half in 1899. It would be also very interesting to state how much of a planetary system Polaris of Ursa Minor possesses, including its three suns, its two telescopic suns, or only the largest sun; but such absolute knowledge is at present far, far beyond any information that flashes to us across the titanic abysses of interstellar space.

Amid the darkness, the silence of evening a star-gazer stands shadowless beneath suns almost incomparable in their remoteness. No cloud, no moon, no planet shining brightly. No electric light, no lamp in a window, no sudden gleaming ray as some automobile passes swiftly. Darkness on all sides, darkness everywhere except far, far overhead, in the firmament sparkling with jewels of fire. In the south incomparable Sirius is scintillating like a fiery diamond; above Sirius Orion glitters; above Orion ruddy Aldebaran and beautiful Capella. Northwardly the eye of our star-gazer roves, all seems dark and devoid of suns after the glorious galaxy in the south. But due north a smaller star twinkles, not particularly noticeable, about half-way from Capella to where blue Vega sparkles on the horizon. It is Polaris, and at once the star-gazer knows exactly the sky-directions around him. On his own planet-home, wars and rumors of wars may come, nations, dynasties rise and fall, generations pass away, he himself will die; but overhead, framed by the ebon background of star-lighted night, Polaris will glitter unextinguishably on, the pole star of his grandfathers, the north star of his grand children.

Boston, Mass.
Technology Chambers.

Fig. 1
Phillips
359° **A**

Fig. 2
Pickering
0° **A**

Fig. 5
Phillips
74° **B**

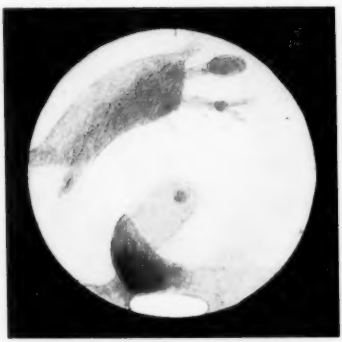


Fig. 6
Pickering
61° **B**

Fig. 9
Phillips
110° **C**

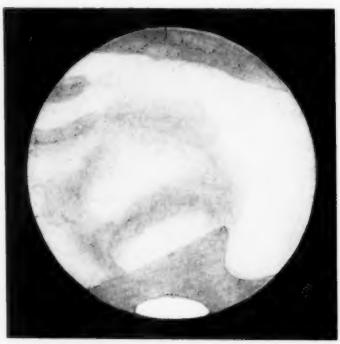


Fig. 10
Pickering
126° **C**

Fig. 3
Wilson
1° **A**

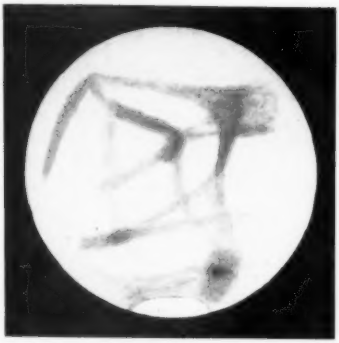


Fig. 4
Douglass
4° **A**

Fig. 7
Wilson
45° **B**

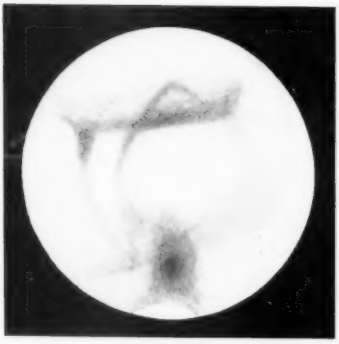


Fig. 8
Douglass
33° **B**

Fig. 11
Wilson
127° **C**

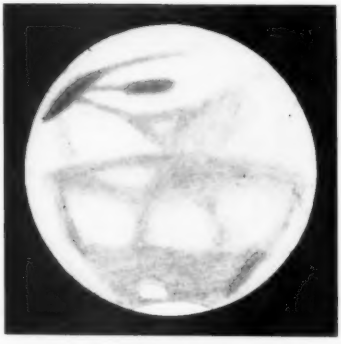


Fig. 12
Douglass
107° **C**

REPORT ON MARS, No. 17.

WILLIAM H. PICKERING.

The Work of the Associated Observers of Mars.

This organization was founded in 1913. Its object, besides general work on Mars, in part coöperative, is to obtain and publish a collection of the best drawings of the planet available, systematically arranged at each successive opposition, for the use of future astronomers. This is necessary, because the details of the surface are constantly changing, not only with its varying seasons, but also at the same season, from year to year. Well known markings constantly disappear, or shift their positions, while others previously unknown are at the same time making their appearance. By the study of these constant changes, it is hoped that future astronomers may be able to draw conclusions regarding the character of the life supported by the planet, and it is possible also that they may even gather information that will be of use to ourselves.

The scope of the Association is entirely international, and sets of drawings have been received this year from Europe, America, and the Pacific. The best six were selected, three being by European, and three by American observers. Anybody interested, and willing and able to make the drawings according to the specifications (Reports 8, 11, and 15), is invited to forward his work to the writer at the close of the coming opposition, and the best series received will be published.

The drawings here shown, like those of the previous opposition published in Report No. 8, are arranged in six horizontal rows. The upper row represents region **A** upon the planet, each drawing being made with meridian 0° as nearly central as practicable. The central meridians of the other regions are 60°, 120°, 180°, 240°, and 300°. Each vertical column represents the work of a single observer, and gives a complete view of the surface of the planet The previously adopted plan was to arrange these columns according to the longitude of the observers, the left hand drawings in general therefore preceding in date those that followed them. Since there are 36 drawings this year, involving six plates, it is not possible to present all six drawings of each region at a single view, as heretofore, and this plan has had therefore to be slightly modified. The observers have been divided into two groups, the first group of four employing the largest instruments, whose extreme range of aperture is nevertheless not very great, and the second group of two, the smaller ones.

The names and addresses of those whose work has been selected for publication together with their equipment, are as follows:

Rev. T. E. R. Phillips, Epsom, England. 12¼-inch reflector by Calver, and 8-inch refractor by Cooke. Magnification employed 275 to 600. Seeing on Standard Scale ranging from 6 to 10, where the higher the number, the better the seeing.

Professor W. H. Pickering, Mandeville, Jamaica. 11-inch refractor by Clark. Magnification 430 and 660. Seeing on Standard Scale ranging from 5 to 12.

L. J. Wilson, Esq., Nashville, Tennesse. 11-inch reflector made by himself. Magnification 360. Seeing 8 to 10 on Standard Scale.

Professor A. E. Douglass, Tucson, Arizona. 8-inch refractor by Clark. Magnification 350 and 450. Seeing on Standard Scale ranging from 6 to 9.

Dr. H. E. Lau, Hörsholm, Denmark. 3¾-inch refractor by Bardou. Magnification 170 and 300. Seeing on personal scale ranging from 1 to 3, where 1 is very fine, 2 good, and 3 rather bad.

H. McEwen, Esq., Glasgow, Scotland. 5-inch refractor by Wray. Magnification 160 to 200.

In Table I are given the fundamental data regarding the figures as far as they could be determined. The first seven columns require no explanation, the eighth gives the central longitude of each drawing, the ninth its difference from the proposed value, the tenth the central latitude, the eleventh the angular diameter of the planet, corrected from that given in the ephemeris, the twelfth the solar longitude as seen from the planet, and the last the corresponding Martian date as deduced from Report No 10.

In Report No. 8 we saw that the planet presented a somewhat different appearance to the observers of the Lowell Observatory from that which it did to the other three. The present six observers on the other hand, all see it very much alike. Any one of the thirty-six drawings herewith shown would be satisfactory to the writer, as indicating the general appearance under certain more or less favorable conditions. If there is any difference at all among them in the style of representation, it would appear to him as if his own drawings and those of Mr. Phillips gave the broader canals a more curving shape and the resulting appearance of the planet a less angular aspect, than is shown in some of the others. This is most marked in regions **D**, **E**, and **F**. Observers at the next opposition should endeavor to determine which of these two appearances is the more correct. Dr. Lau's drawings seem rather lacking in detail as compared with the other figures, and this is undoubtedly due to his very small aperture, only 3¾ inches, yet he shows a very considerable number of canals, as we shall see later, when we deal with the matter statistically.

TABLE I.

FUNDAMENTAL DATA OF THE FIGURES.

No.	Obs.	Aper.	Magn.	Seeing	1916	Reg.	Long.	Δ Long.	Lat.	Diam.	⊙	M.D.
							°	°	°	″	°	
1	Pl	—	—	6 (?)	Feb. 27	A	359	− 1	+15	13.2	60.2	May 17
2	Pk	11	660,430	9, 7	Mar. 5	"	0	0	14	12.5	63.2	" 23
3	W	11	360	—	Jan. 23	"	1	+ 1	18	13.2	44.7	Apr. 38
4	D	8	450,350	7, 9	Mar. 7	"	4	+ 4	14	12.3	64.0	May 25
5	Pl	12, 8	—	8 (?)	Feb. 19	B	74	+14	15	13.6	56.5	" 8
6	Pk	11	660,430	7	Feb. 26	"	61	+ 1	15	13.2	59.7	" 16
7	W	11	360	—	Feb. 24	"	45	−15	15	13.3	58.8	" 14
8	D	8	350	6, 7	Mar. 1	"	33	−27	14	13.0	61.5	" 19
9	Pl	12, 8	—	10	Feb. 19	C	110	−10	15	13.6	56.5	" 8
10	Pk	11	430	6, 5	Feb. 24	"	126	+ 6	15	13.3	58.8	" 14
11	W	11	360	—	Feb. 16	"	127	+ 7	16	13.7	55.3	" 6
12	D	8	350	7	Feb. 26	"	107	−13	15	13.3	59.7	" 16
13	Pl	12, 8	—	7	Feb. 8	D	175	− 5	16	13.9	51.8	Apr. 54
14	Pk	11	660	10	Feb. 12	"	179	− 1	16	13.8	53.6	May 2
15	W	11	360	—	Feb. 14	"	183	+ 3	16	13.8	54.5	" 4
16	D	8	350	8	Feb. 17	"	158	−22	15	13.7	55.7	" 7
17	Pl	8	—	7	Feb. 5	E	240	0	17	13.8	50.4	Apr. 51
18	Pk	11	660	9	Feb. 7	"	242	+ 2	16	13.9	51.4	" 53
19	W	11	360	—	Feb. 10	"	250	+10	16	13.9	52.8	" 56
20	D	8	350	8	Feb. 7	"	256	+16	16	13.9	51.4	" 53
21	Pl	8	275,387	7	Jan. 22	F	315	+15	18	13.2	44.2	" 37
22	Pk	11	430	10, 12	Mar. 9	"	303	+ 3	14	12.2	65.0	May 27
23	W	11	360	—	Feb. 3	"	303	+ 3	17	13.8	49.7	Apr. 49
24	D	8	350	9	Mar. 13	"	287	−13	14	11.7	66.7	May 31
25	L	4	170,300	1	Feb. 20	A	350	−10	15	13.6	57.0	" 9
26	M	5	180	—	Feb. 20	"	4	+ 4	15	13.6	57.0	" 10
27	L	4	170,300	2, 3	Feb. 15	B	62	+ 2	16	13.8	55.0	" 5
28	M	5	200	—	Feb. 16	"	64	+ 4	16	13.7	55.5	" 6
29	L	4	170,300	1	Feb. 8	C	128	+ 8	16	13.9	51.7	Apr. 54
30	M	5	180	—	Feb. 9	"	124	+ 4	16	13.9	52.2	" 55
31	L	4	170,300	1, 2	Jan. 27	D	213	+33	18	13.5	46.6	" 43
32	M	5	160	—	Feb. 4	"	184	+ 4	17	13.8	48.1	" 50
33	L	4	170,300	2	Jan. 27	E	244	+ 4	18	13.5	46.5	" 42
34	M	5	160	—	Jan. 28	"	230	−10	17	13.5	47.0	" 44
35	L	4	170,300	1, 2	Feb. 23	F	304	+ 4	15	13.4	58.2	May 12
36	M	5	160	—	Jan. 22	"	303	+ 3	18	13.2	44.2	Apr. 37

Mr. Phillips describing his own work says that it was done under certain disadvantages, on account of the removal of his observatory from Ashtead to Headley. He had no driving clock on his reflector until after February 8. He also had a good deal of bad weather. He thinks there was considerable haze or mist in the Martian atmosphere early in the season, soon after the melting of its northern polar cap.

In speaking of the region of Nilokeras and Lunae Lacus, regions **B** and **C**, Figures 5 and 9, which he observed under unusually favorable circumstances, he says "the general appearance of this region is totally un-Lowellian in character, and the term canal altogether unsuitable." He remarks especially on the unexpected invisibility of the Ganges. On March 3 the preceding end of the polar cap was much darker than the following end. This was undoubtedly due to cloud over the former. He indicates certain cloudy regions by dotted lines in Figure 21.

The writer would point out that the clouds always lie over the so-called desert regions of the planet, apparently being precipitated as soon as the fertile regions are reached. This is clearly shown in Figure 14, where the cloud following Charontis is also indicated, half covering Elysium. This was not an unusual feature in this region in the Martian mornings, indicating doubtless that Charontis like Acidalium is composed of moist or marshy land. Incomplete canals, i. e. elongated marshes disappearing in the desert, are shown in many of the drawings, by most of the observers. Such a thing like an incomplete canal was formerly supposed not to exist. The broad hazy character of some of the early markings is clearly shown in Figure 10. These darker areas will it is expected later develop into well defined canals. In most of the Jamaica drawings the canals are still broad and curved, but in the last one secured, Figure 22, the straight narrow canals had already begun to form, and were not afterwards absent from that side of the planet.

In a letter from Mr. Wilson he speaks of the bad weather during the past winter. He also points out particularly the small projection due to cloud shown on the morning terminator of Figure 7, located over the region just following Solis Lacus. Clouds were frequently noted on the northern side of the dark regions of the planet, as in Figures 15 and 23.

Professor Douglass sends several notes relative to the clouds visible on the planet, and calls particular attention to the small white spot near the polar cap shown in Figure 12. Regarding their frequent rapid dissolution, which we have mentioned in some of our earlier reports, he notes that on February 7 at $15^h\ 45^m$ G.M.T. both sides of the Syrtis were whitish. Half an hour later only the following side remained so. This was in the early Martian morning.

Dr. Lau shows bright cloudy areas by means of dotted lines in several of his drawings, but makes no reference to them in his letter of transmission. Mr. McEwen sends a set of beautiful colored sketches in red, yellow, and violet, which it is a pity should have to be reproduced in simply black and white. Like all the other observers he shows well marked cloudy areas. But a few years ago some observers claimed that unlike the Earth, clouds were never seen on Mars, or at all events were extremely rare. During the present opposition the planet has scarcely ever been seen without them.

The More Important Divergencies of Representation.

It will be noticed that in Figure 3 Aryn, lying within the forked bay of Sabaeus, is represented as having appeared, to be sure rather vaguely, as early as January 23. This the writer believes is an error. To Messrs. Lau and McEwen it was invisible as late as February 20 (Fig-

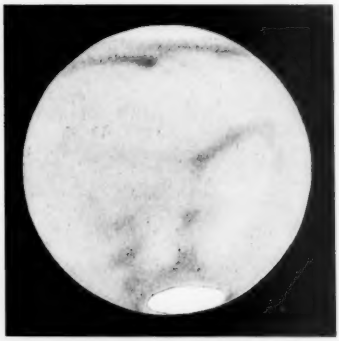


Fig. 13
Phillips
175° **D**

Fig. 14
Pickering
179° **D**

Fig. 17
Phillips
240° **E**

Fig. 18
Pickering
242° **E**

Fig. 21
Phillips
315° **F**

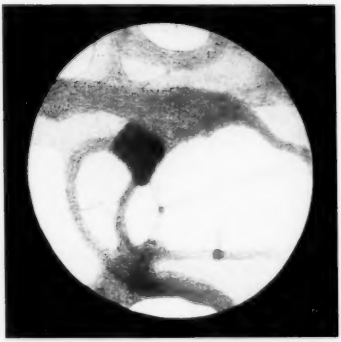


Fig. 22
Pickering
303° **F**

Fig. 15
Wilson
183° D

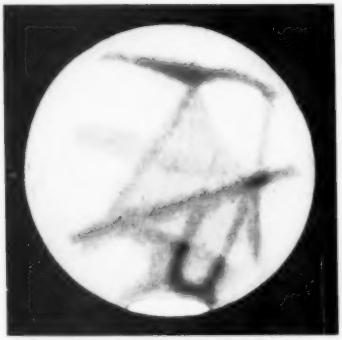


Fig. 16
Douglass
158° D

Fig. 19
Wilson
250° E

Fig. 20
Douglass
256° E

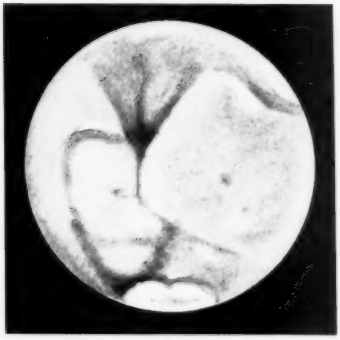


Fig. 23
Wilson
303° F

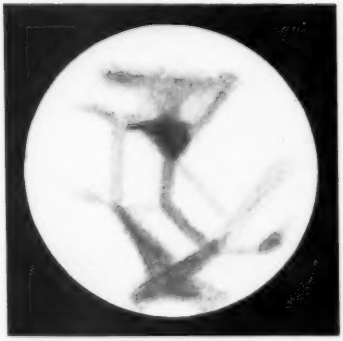


Fig. 24
Douglass
287° F

ures 25 and 26). If well defined, it should have been visible in their telescopes. Mr. Phillips shows it in Figure 1, drawn February 27. To the writer it was first suspected March 1, and clearly shown although only slightly marked March 5 (Figure 2). March 7 Professor Douglass writes regarding it, "Sabaeus Sinus possibly double, not sure." He does not show Aryn however in his sketch of that date (Figure 4). It may therefore be taken as fairly certain that it first became visible this year early in March. $\odot$ 62° ± 2°, M. D. May 21. On the other hand it should be noted that Dr. Lowell shows it very conspicuously in his sketch of January 28, published in POPULAR ASTRONOMY 1916, **24** Plates 26 and 27, 423, 426. He apparently did not notice that it was then invisible. The writer has an excellent drawing made January 30, seeing 9, which shows not a trace of it.

As an illustration of the differences that are sometimes found in the work of different observers, the canal Laestrigon is shown on Figures 15 and 19 by Mr. Wilson, and on Figures 16 by Professor Douglass as a straight line, yet on February 12 to the writer (Figure 14) it was clearly crooked. On March 21 and 24, however, he too drew it as straight. If it really was crooked, this shows about the maximum length of an average curved canal that present appliances will erroneously indicate as a straight line. Its length was 2″.8, or 800 miles, (1200 km).

This statement is corroborated by the fact that the larger telescopes, in Figures 14, 17, 18, and 20, represent Elysium as circular. In Figure 13 it is slightly angular and in Figures 15 and 19 clearly so, with four straight bounding canals. The circular form is confirmed by a drawing sent me some months ago, made at the observatory of M. Jarry-Desloges with a 12-inch objective. Dr. Lowell in his paper in POPULAR ASTRONOMY, above mentioned, represents it still differently, with two straight sides and two curving ones, giving it a rather hexagonal form, but agreeing fairly well in general appearance with the majority. This is much too difficult a point to be decided by a small telescope, but it is of interest to note that in Figure 34 Mr. McEwen represents it as a square, strongly inclined to the position shown by Mr. Wilson in Figure 19, and that in Figure 32 one of the sides is slightly curved. In former oppositions it was often represented as a pentagon, with a strongly marked angle at the south. In 1916, however, it appeared circular to the writer.

No such rapid changes of detail are recorded on our drawings this year as were found in 1914. Indeed it is rather too late in the Martian season for such changes to present themselves, but there is nevertheless evidence of a flooding of the Syrtis marsh on two occasions. It will be recalled that one flood occurred about the end of December (Reports Nos. 14 and 15). The Syrtis then narrowed and dried up, as shown in

Figures 21 and 36, both taken on the same date, January 22. A very slight darkening is shown in both of them, but it is so slight that the observers do not agree very well as to its location.

Another flood occurred January 31, ☉ 48°.3, as recorded on the Jamaica drawings, the flood broadening and spreading for the next few days, but by February 3 (Figure 23) Mr. Wilson shows that it had already begun to recede towards the northern tip of the Syrtis. The longitudinal canal Dosaron, however, still marked its central axis. The increased breadth of the Syrtis was now clearly noticeable. This recession of the marsh is confirmed by a Jamaica drawing of February 7. By February 23 (Figure 35) Dr. Lau shows that the Syrtis had again narrowed, and the dark area and canal had entirely disappeared. The canal is however faintly shown in a drawing by Mlle. Renaudot, made at Juvisy February 24, and more conspicuously in a drawing by M. Le Coultre of Geneva, dated March 1. It is is further shown in a drawing by M. Dufour on the same date (L'Astronomie 1916 **30**, 308, 269, and 270). The narrowing of the Syrtis and disappearance of the dark area is confirmed by all three of these drawings.

By March 9 (Figure 22) the Syrtis had broadened again, and the dark flooded area had become quite conspicuous. Four days later (Figure 24) according to Professor Douglass, the flood had receded slightly, and Dosaron had begun to appear, but the width of the Syrtis was still as great as ever. This is the last great flood in this region of which we have any evidence. ☉ 65°, M. D. May 27. The approximately square flooded area measured at maximum about 700 miles (1100 km) on a side, thus indicating the power of our Sun even at the distance of Mars.

As pointed out two years ago, these floods on the Syrtis should be carefully observed in the springtime of the Martian year. Every interested observer should draw the Syrtis every night that it is visible to him at the next opposition, timing his drawing so that the Syrtis shall be as near as possible to the central meridian. See Report No. 15 for instructions how to compute the time. Then by combining the observations made in Europe with those made in America, we could get a series of drawings for this particular Martian longitude extending through fully a half presentation of the planet, or twenty days. The next opposition will be our last chance for several years. When a flood comes it begins to darken first towards the tip of the Syrtis, and gradually spreads and broadens, turning first dark and then blue. At length the southern boundary of the dark spot, which was at first indistinct, becomes sharply defined, and this gives us our first definite date for the flood. The blue color and the sharpening of this boundary are the most definite indications that we have, and observers should be particularly on the lookout for them in the future.

Identification of the Canals.

The identification of the canals and lakes of this opposition has been made by means of our standard map published in connection with Report No. 15. This map, which is probably the best yet constructed, has proved very satisfactory, and much better than its predecessor, but careful study has shown certain defects in it which may be pointed out in this place. It would be better if it contained a few more canals, and also a few more lakes. As in the case of the previous opposition, it has been necessary occasionally to refer for an identification to Lowell's map of 1896 (Annals **3**, 100) and sometimes to his other maps, and to that of M. Jarry-Desloges (Observations **3**). Several of the canals shown are taken from Lowell's maps, but one of them, Evenus, leading north-easterly from Titanum Sinus is wrongly named. It should be called Steropes, Evenus according to Lowell indicating another canal in the immediate vicinity. Cyclops to the north of Elysium should be considerably more inclined, as it was drawn by Schiaparelli. Nuba Lacus, situated on Thoth, should, according to all observers who recorded it this year, be located appreciably farther to the south,—perhaps 10° for the average. There seems to be some ambiguity about a few of the canals to the north of Solis Lacus, lying between Aurorae Sinus and Phoenicis Lacus. The accompanying sketch map Figure I shows the

Fig. 1

names which it has been decided to adopt in these Reports. The three small lakes are Messeis, Tithonius and Phoenicis, the first named by Lowell in 1896 (Annals **3**, 100).

The canal N M as is shown by the standard map is Agathodaemon, so named by Schiaparelli.

The canal M T P is Daemon, so called by Lowell in 1901 (Annals **3**, 144).

The canal A M has been called Agathodaemon by Lowell in 1896, 7, (Annals **3**, 100). It has been called Coprates by Desloges in 1912, (Observations **3**, 317) but this name Lowell has already applied to another canal in this immediate vicinity. On our standard map the name Ophir has been placed immediately below it, but the type employed indicates

a region, not a canal. The name Ophir is however a good one, and it is proposed to adopt it for this canal.

The canal ST is Tithonius, so named by Lowell (Annals **3**, 100).

The little crooked canal MK is occasionally prolonged to T. It was first seen, it is believed, by the writer in 1892, when it was also drawn by Professor Douglass. It appeared again in 1914 (See Report No. 8), where it was sketched by Professor Douglass, Figure 7. It had again appeared this past year, see Figures 6 and 12. In the Lowell Annals **2** the name Agathodaemon has been applied to a portion of it, on a map which has been superseded in Volume **3**, Append. 24. On the latter map this use has been discontinued. It is otherwise unnamed. It is now proposed to call it Kedron.

The identification of a large number of canals and lakes always involves the exercise of a certain amount of judgment, for not only do the observers themselves sometimes draw them in the wrong places, but also, in the case of the canals, sometimes in the wrong position angle. Moreover, as we have already seen, these objects sometimes shift their positions, travelling occasionally several hundred miles over the surface of the planet. If even the clearly marked ones, whose latitudes and longitudes we are able accurately to determine, do this, what shall we do with the fainter ones, which we can only just distinguish? Under the circumstances it is perhaps surprising that any two specialists will agree on the proper names for the markings as well they do, or that the same observer will corroborate his own identifications at different oppositions. Of course the conspicuous markings are easy enough; it is usually only the fainter ones that give trouble.

The best method to adopt, is first to determine the latitude and longitude of the central point of the disk, and then to name the more obvious markings. We next determine the latitude and longitude of any point near the centre by means of a central point. It is always well to identify the lakes first. For the canals their position angles will also help. Finally in many cases assistance may be derived from the neighbouring detail.

In Table II is given a list of all the canals shown on the drawings of the six observers. The canals are arranged and numbered alphabetically, and the successive columns indicate in which drawings of each observer the canal is found.

The dark areas bounded on one side by the polar cap, and which often coincide more or less closely in position with some of the canals given on the map, are not considered to be really canals, unless they are clearly separated from the snow. As shown in Report No. 14 they appear to be more ephemeral in their nature, often changing in breadth and visibility in the course of a few hours, and in any case clearly

Fig. 25
Lau
350° **A**

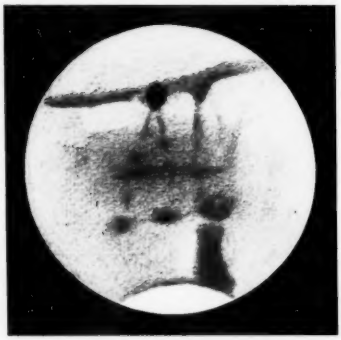


Fig. 26
McEwen
4° **A**

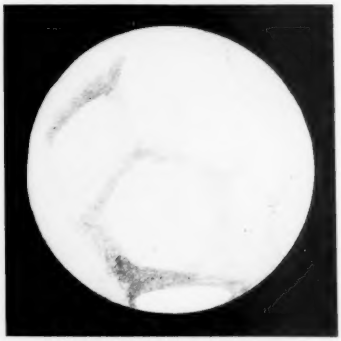


Fig. 27
Lau
62° **B**

Fig. 28
McEwen
64° **B**

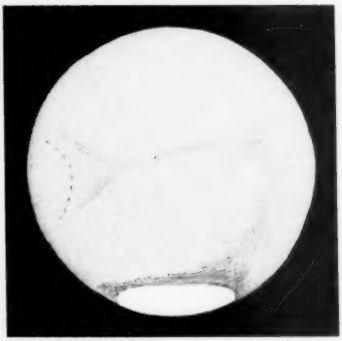


Fig. 29
Lau
128° **C**

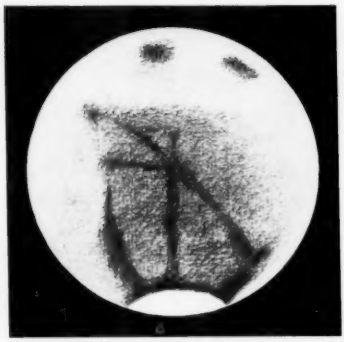


Fig. 30
McEwen
124° **C**

PLATE XLV

Fig. 31
Lau
213° **D**

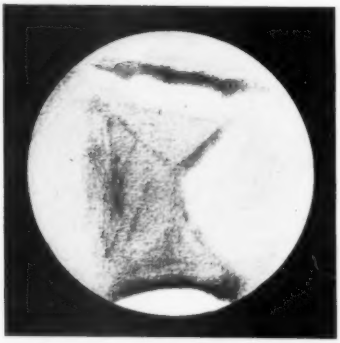


Fig. 32
McEwen
184° **D**

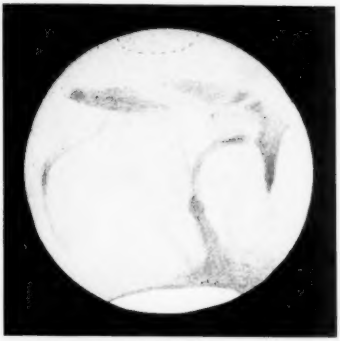


Fig. 33
Lau
244° **E**

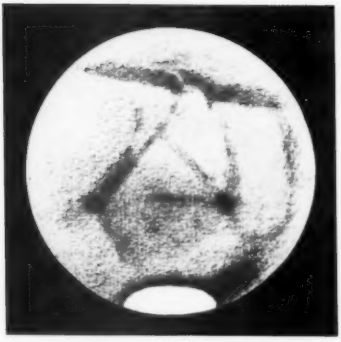


Fig. 34
McEwen
230° **E**

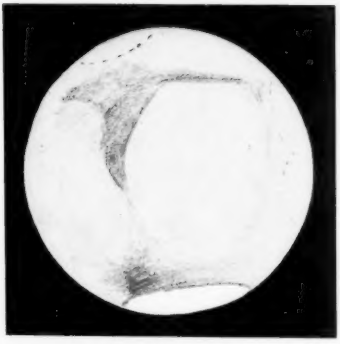


Fig. 35
Lau
304° **F**

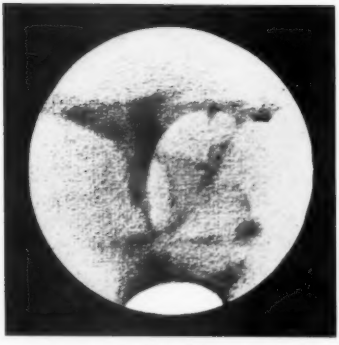


Fig. 36
McEwen
303° **F**

TABLE II.

CANALS IDENTIFIED ON THE DRAWINGS.

No.	Canal	Pl	Pk	W	D	L	M	Obs.
1	Acheron		C *		D			2
2	Aesacus			E				1
3	Aethiops						E	1
4	Alander (L)					BC		1
5	Anian			DE				1
6	Asopus						F	1
7	Astusapes		F	DE	F		F	4
8	Avernus		D				D	2
9	Boreas		E					1
10	Boreosyrtis	E	E	F	EF		F	5
11	Bosporus		B		C			2
12	Brontes	C	D	D	CD	C	C	6
13	Casius	EF	EF	FF	EF	EF	E	6
14	Ceraunius	C	C	C	C	B	BC	6
15	Cerberus	DE	DE	DE	DE	DE	DE	6
16	Chaos		DE	DE				2
17	Chlorus (L)				B			1
18	Cyane (L)				B			1
19	Cyclops	E	DE	E	E	DE	E	6
20	Daemon (L)	BC	BC		C			3
21	Dargamanes (L)				B			1
22	Deuteronilus	FA	FA	A	AB	A	A	6
23	Dosaron (L)			F	F			2
24	Erebus		D		D		D	3
25	Eumenide	D	C		D			3
26	Eunostos	DE	DE	DE	EF	D	E	6
27	Euphrates	F	F	A	A		F	5
28	Fortuna			C				1
29	Ganges		B	B	BC			4
30	Gehon		A	AB	AB		A	4
31	Gigas		C	C	C	C	C	5
32	Granicus			D				1
33	Hades	D	DE	D	D		D	5
34	Hebrus			C			C	2
35	Hephaestus		E	E	E			3
36	Hiddekel					F	A	2
37	Hyblaeus	E	DE	E	E	D		5
38	Hydaspes						AB	1
39	Indus		A	AB	AB	B	A	5
40	Jamuna			B				2
41	Jordanis				A		AB	2
42	Kedron (P)		B		C	A		2
43	Laestrigon		D	DE	D			3
44	Laus (L)				E			1
45	Lycus		C	C	C			4
46	Nar (L)			E			C	2
47	Nasamon		F		F		E	2
48	Nectar	BC	B	B	BC			4
49	Nepenthes	EF	EF	EF	E	E		5
50	Nilokeras	BC	A	B	B	AB		6
51	Nilosyrtis	EF	EF	EF	EF	EF	B	6
52	Nilus	C			C	B	F	3
53	Ophir (P)	BC	B	B	C			4
54	Orcus	D			D			3
55	Oxus		A	A	A		D	3
56	Pandora	F	F	A	A			5
57	Phison	F			F		F	2
58	Phryxus (L)							1
59	Protonilus	FA	FA	FA	FA	F	F	6

* EDITOR'S NOTE:—The letters in this table refer to the corresponding heavy face letters in the titles of Figures.

TABLE II.—CONTINUED.

No.	Canal	Pl	Pk	W	D	L	M	Obs.
60	Pyramus			F				1
61	Simois		D					1
62	Sirenius					B	C	2
63	Sitacus	F	F	A	A		F	5
64	Steropes (L)				D			1
65	Styx	D	DE	DE	D	DE	DE	6
66	Subus (D)		F	F	F			3
67	Tartarus		D		D			2
68	Thoth	EF	EF	EF	EF	EF	E	6
69	Titan						D	1
70	Triton		E	E	EF	E	E	5
71	Uranius	C			C		B	3
72	Anon. (*a*)				A	A		2
73	" (*b*)					E		1
74	" (*c*)					E		1
75	" (*d*)						A	1
76	" (*e*)						D	1
77	" (*f*)						D	1

differ from the canals properly so called. In accordance with this view they have been omitted from the table. Ten canals not given on our map have been identified on that of Dr. Lowell. Their names are all followed by an (L). One canal, Subus, followed by a (D) was identified on the map of M. Jarry-Desloges. Six other canals could not be identified, and are recorded as anonymous. They may be described briefly as follows:

Anon. (*a*) This canal lies just to the south of Deuteronilus. It connects with Margaritifer through Oxus which has shifted to the south to connect with it, and now leads directly to Ismenius instead of to Siloe.

Anon. (*b*) Preceding and nearly parallel to Casius.

Anon. (*c*) Following and nearly parallel to Casius.

Anon. (*d*) Parallel to Deuteronilus and 0.4 of the distance towards Sabaeus.

Anon. (*e*) Preceding Titan and slightly inclined to it.

Anon. (*f*) Following Titan and slightly inclined to it.

The last column of the table gives a number of observers by whom each canal was seen.

STATISTICS OF THE CANALS.

A statement of the number of canals recorded is given in Table III, where the first column indicates the visibility, by the number of observers who recorded the canals, and the following columns the

number of such canals recorded by each observer, and the total. Thus, of those canals recorded by all six observers, Mr. Phillips saw 12, of those recorded by five observers, he saw 7, etc. The next to the lowest horizontal row shows the number of canals seen that were confirmed by at least one other observer, and the lowest row the total number seen. The three southern observers saw more canals than the three northern ones, which was perhaps to be expected, since the seeing seems to be a function of the latitude. Indeed they each saw all of the canals recorded by six, five, and four observers, 28 altogether. They saw 32 canals in all in common. It was only in the canals seen by but three observers where they began to break down. The last column shows that there were ten of these, all of which were seen by Professor Douglass. Dividing the observers into these two classes, it would seem that the special usefulness of the northern observers was to classify the more conspicuous canals as to their relative visibility, and to confirm the fainter canals when possible. The usefulness of the southern observers is to find the fainter canals, and determine their relative visibility when found. Both classes of observers are therefore needed in this investigation. It cannot be too strongly emphasized however that all the drawings are useful for studying the existence, location, and shapes of the more conspicuous markings, and that this work is considered of far more importance than the discovery of the fainter canals, Observers are again cautioned not to see too many faint and doubtful canals.

TABLE III.

THE NUMBER OF CANALS RECORDED.

Obs.	Pl	Pk	W	D	L	M	Total
6	12	12	12	12	12	12	12
5	7	10	10	10	5	8	10
4	2	6	6	6	1	3	6
3	5	7	4	10	1	3	10
2	1	7	5	9	4	6	16
1	0	2	6	4	4	7	23
Confirmed	27	42	37	47	23	32	54
Total	27	44	43	51	27	39	77

Owing to the fact that Mr. Wilson's observatory is so near the track of the great anti-cyclone disturbances, which are undoubtedly the prime source of all the bad seeing that we experience, he might properly be classified with the northern observers, whom he would then lead as far as the number of canals recorded are concerned. He really holds a position intermediate between the two classes, but owing to the lack of southern observers we have classified him with them.

On the principle of the division of labor among the observers, it has been decided, even at the risk of losing several of the canals that were really there, to omit all those recorded by the northern observers which were not confirmed by at least one of the southern ones. This measure has not been applied to the canals recorded at the southern observatories, because it seemed more likely that a favorably situated observer, such for instance as Professor Douglass, who saw a great many canals that were confirmed by others, might very well have seen a few which no one else had recognized. This plan will eliminate the following canals from our list:—Aethiops, Alander (L) Asopus, Cyane (L), Hiddekel, Hydaspes, Sirenius, Titan, and five of the six anonymous canals. This reduces the total number of canals from 77 to 64. It should be pointed out that this does not indicate the total number of canals seen by all of the observers at this opposition, but only the total number seen on certain selected drawings. Earlier and later, moreover, other canals appeared not here recorded.

On our finally accepted list the following canals have been seen by all six of the observers: Brontes, Ceraunius, Cerberus, Cyclops, Casius, Deuteronilus, Eunostos, Nilokeras, Nilosyrtis, Protonilus, Styx, and Thoth.

Five observers saw Boreosyrtis, Euphrates, Gigas, Hyblaeus, Hades, Indus, Nepenthes, Pandora, Sitacus, and Triton.

Four observers saw Astusapes, Gehon, Ganges, Lycus, Nectar, and Ophir.

Three observers saw Daemon, Erebus, Eumenides, Hephaestus, Laestrigon, Nilus, Orcus, Oxus, Subus, and Uranius.

Two observers saw Acheron, Avernus, Bosporus, Chaos, Dosaron, Hebrus, Jamuna, Jordanis, Kedron, Nar, Nasamon, Phison, Tartarus, and Anonymous (*a*).

One observer only saw Aesacus, Anian, Boreas, Chlorus, Dargamanes, Fortuna, Granicus, Laus, Phryxus, Pyramus, Simois, and Steropes.

The arrangement of Table IV is similar to that of Table III, except that instead of giving the total number of canals seen by each observer, it gives the proportion of the total number recorded. These total numbers are given in the last column, as modified by the above mentioned omissions. As we descend the columns to fainter and fainter canals, the proportion of the total number seen by each observer should rapidly decrease, and this we find in general to be the case. We note by the last column that as the canals grow fainter, they first decrease, and then increase in numbers, averaging eleven to each class. The lower row of the table gives the modified number of canals seen by each observer.

TABLE IV.

PROPORTION OF THE CANALS VISIBLE TO THE DIFFERENT OBSERVERS.

Obs.	Pl	Pk	W	D	L	M	Total
6	1.00	1.00	1.00	1.00	1.00	1.00	12
5	.70	1.00	1.00	1.00	.50	.80	10
4	.33	1.00	1.00	1.00	.17	.50	6
3	.50	.70	.40	1.00	.10	.30	10
2	.07	.50	.36	.64	14	.29	14
1	.00	.17	.50	.33	.00	.00	12
Total	27	44	43	51	21	30	64

In the opposition of 1914 nearly all the canals were broad, while the more difficult ones were faint. To detect them therefore did not require particularly good seeing, but it did require an eye sensitive to small contrasts. In 1916 more narrow canals appeared, especially immediately after the opposition, good seeing was therefore more important. It is expected that still more of the narrow canals will appear in 1918. These will require large apertures, that is to say as large as the climate of the observer will permit. Apertures as large as 12 inches can probably be used to advantage at times in northern Europe, and still larger ones in the Mediterranean section. Observers should not forget, however, that when the seeing is poor, a very appreciable advantage may be gained, on bright objects like the Moon and Mars, by reducing their apertures.

COMPARISON OF THE OPPOSITIONS OF 1914 AND 1916.

Comparing the past year's work with that of the previous opposition (Report No. 8), we notice first that the present drawings were made appreciably later in the Martian calendar year. The earlier observations were all taken between $\odot$ 5°.5 and 26°.1, corresponding on the Revised Calendar of Report No. 10 to between the Martian dates of March 12 and 54. By Table I, the present set of drawings were made between $\odot$ 44°.2 and 66°.7 corresponding to the Martian dates of April 37 and May 31. As a result on comparing the two sets of drawings, we notice at once that the northern snow cap has appreciably decreased in size. It has turned also more directly towards us. In 1914 the central latitude lay between +2° and +9°. This year it lay between +14° and +18°. The maximum size of the planet was somewhat less, 13″.9 against 15″.0,—indeed such a remote opposition is unusual, and will not occur again for many years.

There was a general complaint of poor seeing among the different observers. Professor Douglass found little difference, however; his range of seeing on the standard scale in 1914 was 5 to 9, and in 1916, 6 to 9.

For the writer in 1914 it was 10 to 12, averaging 10.5, and this year 5 to 12, with a rather low average of 8.4. Yet in spite of the smaller disk and poorer seeing, he saw more canals, and they were increasing in number when the time limit for the drawings expired. Moreover this year there were no canals visible in the Protei regio, region **B**, where owing to a flood a number were seen before.

Treating the matter statistically with regard to the more conspicuous and therefore assured canals, we find that in 1914 there were 24 that were seen by all three observers. Three of these lay at the border of the polar cap, and adopting this year's regulation, they were eliminated as not being really canals, properly speaking. Achelous (L) also, in fact appeared on only two of the drawings in 1914, Mr. Phillips' representation coinciding more nearly with Cyclops than Achelous. Phlegethon was very faint on two of the drawings, so much so indeed that it shows only in the reproduction of the drawing by Professor Douglass, Figure 15. These canals will also be eliminated, leaving 19, which we will compare with the 22 seen this year, by six and by five observers.

TABLE V.

COMPARISON OF THE CHIEF CANALS SEEN IN 1914 AND 1916.

Part I				Part II			
1914	Vis.	1916	Vis.	1916	Vis.	1914	Vis.
Agathodaemon	6	Ophir	4	Brontes	6	Titan	4
Boreas	6	Boreas	1	Cyclops	6	Cyclops	2
Boreosyrtis	6	Boreosyrtis	5	Euphrates	5	Euphrates	4
Bereosyrtis	6	Casius	6	Hades	5	Hades	4
Cerberus	6	Cerberus	6	Indus	5	Indus	4
Daemon (L)	6	Daemon (L)	3	Protonilus	6	Protonilus	4
Deucalionis	6	Pandora	5	Sitacus	5	Hiddekel	4
Deuteronilus	6	Deuteronilus	6	Triton	5	Triton	4
Eunostos	6	Eunostos	6				
Gigas	6	Gigas	5				
Hyblaeus	6	Hyblaeus	5				
Lapaden (L)	6	Ceraunius	6				
Nectar	6	Nectar	4				
Nepenthes	6	Nepenthes	5				
Nilokeras	6	Nilokeras	6				
Nilosyrtis	6	Nilosyrtis	6				
Styx	6	Styx	6				
Tartarus	6	Tartarus	2				
Thoth	6	Thoth	6				
Tithonius	6	——	0				

In the first part of Table V the first column gives these nineteen canals. The second column gives their visibility, calling those seen by all three observers 6. Those that were seen by two observers are marked in another column 4, and those seen but by one observer 2. The third column gives the corresponding canals seen in 1916, and the fourth their visibility taken from the last column of Table II. Since different maps were used in the identification in the two oppositions, this sometimes causes a change in the name of the canal, but allowing

for this fact, in most cases the difference in recorded visibility is not very great. Certain exceptions occur, however, Boreas being seen by but one observer this year, Daemon by but three, Tartarus by two, and Tithonius not at all.

In the second part of the table the first two columns refer to the past opposition, and contain the names of the remainder of the clearly visible canals, the other columns referring to the opposition of 1914. The only marked change recorded is that of Cyclops, which, as above stated, was seen by one observer in 1914. Achelous and Cyclops are parallel and lie side by side, although 700 miles apart, both connecting Cimmerium with Elysium. Since the former was clearly visible in 1914, and the latter alone the past opposition, we may well wonder if the latter really took the place of the former in the physical economy of the planet, and if so in what way.

The Lakes of Mars.

A list of the 33 lakes seen by the different observers is given in Table VI which is arranged exactly like Table II. There are two or three curious points about it. No single lake was seen by all six observers. Ismenius and Lunae were the two most frequently recorded. Oddly enough Solis was not seen at all with the two smaller instruments, presumably because it was so near the southern limb. The two observers who saw the most canals were with one exception the two who saw the fewest lakes. The anonymous lakes were located as follows:—*A* 100°, +30°,

TABLE VI.

Lakes Identified on the Drawings.

No.	Lake	Pl	Pk	W	D	L	M	Obs.	No.	Lake	Pl	Pk	W	D	L	M	Obs.
1	Acidalius (L)				AB			1	18	Nuba	E		EF	E	E		4
2	Ammonium			D				1	19	Orontes (D)			A			A	2
3	Arethusa			A				1	20	Oxia		A					1
4	Ascraeus					C		1	21	Pambotis			DE				1
5	Caloe	F	F	F				3	22	Phoenicis						C	1
6	Castorius				D			1	23	Propontis I	D						1
7	Charontis			DE	D	D	D	4	24	Propontis II	D						1
8	Coloe (L)			F				1	25	Pseboas		F					1
9	Cyclopum (L)				E			1	26	Siloe			A			A	2
10	Hecates	D		E				2	27	Solis	BC	BC	B	C			4
11	Hesperidum (L)				E			1	28	Stymphaline	D						1
12	Ismenius	AF	AF	A	AF		AF	5	29	Triviae (L)			D			E	2
13	Lunae	B	B	B		B	B	5	30	Anon *A*	B						1
14	Maricae			D				1	31	" *B*	D						1
15	Messeis (L)	C	B	C				3	32	" *C*						E	1
16	Morpheos (D)			DE				1	33	" *D*			F				1
17	Niliacus	AB		B		A	A	4									

B 180°, +60°, *C* 235° +20°, and *D* 275°, +25°. Only twelve lakes out of the 33 recorded were seen by more than one observer, which leads one to wonder if all the others were real. These twelve named in the order of their visibility were (5) Ismenius, Lunae, (4) Charontis, Niliacus, Nuba, Solis, (3) Messeis (L), Caloe, (2) Hecates, Morpheos (D), Siloe and Triviae. Of these Wilson saw all 12, Phillips 8, McEwen 7, Pickering 5, and Douglass and Lau 4 each. Only 6 of them were seen at the previous opposition, namely Messeis, Niliacus, Charontis, Solis, Caloe, and Nuba. The last two were those designated as anonymous, numbers 21 and 22, since they were not given either on Schiaparelli's or Lowell's map.

Table VII contains the usual data for the final drawings of the opposition, that were made in Jamaica. These were omitted from the last report on account of its length.

TABLE VII.

DATA OF THE DRAWINGS.

No.	1916	⊙	M. D.	Long.	Lat.	Sun	Diam.	Seeing
		°		°	°	°	″	
68	Feb. 28	60.0	May 18	30	+ 15	+ 21	13.0	10
69	Mar. 1	61.5	" 19	3	14	"	12.9	8, 7
70	" 1	"	" "	35	"	"	"	7, 6
71	" 5	63.2	" 23	0	"	"	12.5	9, 7
72	" 8	64.5	" 26	332	"	22	12.3	9
73	" 9	65.0	" 27	303	"	"	12.2	10, 12
74	" 11	65.8	" 29	273	"	"	12.0	9, 7
75	" 19	69.3	" 37	246	"	"	11.3	6, 4
76	" 21	70.2	" 39	209	"	"	11.0	9, 10
77	" 24	71.5	" 42	180	15	"	10.8	10, 9
78	" 26	72.4	" 44	149	"	23	10.6	7, 8
79	" 29	73.7	" 47	121	"	"	10.3	9, 10
80	" 31	74.5	" 48	96	"	"	10.1	9, 6
81	Apr. 5	76.7	" 54	46	"	"	9.7	8, 10
82	" 5	"	" "	62	"	"	"	11, 12
83	" 6	77.1	" 55	33	16	"	9.6	9, 7
84	" 7	77.6	" 56	9	"	"	9.5	11, 10
85	" 12	79.8	June 5	331	"	24	9.1	6
86	" 17	82.0	" 9	297	17	"	8.6	8, 9
87	" "	"	" "	331	"	"	"	8, 9
88	May 1	88.2	" 23	183	18	"	7.9	6
89	" 3	89.0	" 25	122	"	"	7.8	7, 6
90	" "	"	" "	158	"	"	"	8

The following canals and lakes were seen:

Feb. 28 **A** Protonilus. Deuteronilus.

Mar. 1 **AB** Protonilus, Deuteronilus, Jordanis, Gehon, Oxus, Indus, Jamuna, Nilokeras, Ganges, Chrysorrhoas, Ophir, Anonymus, and Ismenius, Siloe, Oxia.

Mar. 5 **A** Protonilus, Deuteronilus, Gehon, Oxus, Indus, Nilokeras, and Ismenius, Oxia.

Mar. 8	**A**	Nilosyrtis, Protonilus, Deuteronilus, Gehon, Jordanis.
Mar. 9	**F**	Thoth, Nepenthes, Casius, Nasamon, Subus, Nilosyrtis, Asteropes, Sitacus, Euphrates, and Ismenius, Caloe, Coloe.
Mar. 11	**F**	Cerberus, Cyclops, Eunostos, Hyblaeus, Anian, Hephaestus, Nepenthes, Thoth, Casius, Nasamon, Subus, Nilosyrtis, Astusapes, Protonilus, Anonymous.
Mar. 19	**E**	Cerberus, Styx, Cyclops, Eunostos, Hyblaeus, Nepenthes, Thoth, Casius, Nilosyrtis.
Mar. 21	**D**	Erebus, Hades, Styx, Cerberus, Cyclops, Eunostos, Hephaestus, Hyblaeus, Chaos.
Mar. 24	**D**	Lycus, Brontes, Erebus, Tartarus, Hades, Styx, Cerberus, Cyclops, Eunostos, Hyblaeus.
Mar. 26	**C**	Gigas.
Mar. 29	**C**	Daemon, Ceraunius, Gigas, and Solis.
Mar. 31	**C**	Jamuna, Nilokeras, Ganges, Chrysorrhoas, Nilus, Ophir, Daemon, Kedron, Ceraunius, Gigas, Iris, and Solis.
Apr. 5	**BB**	Oxus, Indus, Iaxartes, Tanais, Jamuna, Nilokeras, Ganges, Chrysorrhoas, Uranius.
Apr. 6	**B**	Gehon, Deuteronilus, Oxus, Indus, Callirrhoe, Iaxartes, Tanais, Nilokeras, Ganges.
Apr. 7	**A**	Protonilus, Deuteronilus, Jordanis,[1] Gehon, and Ismenius.
Apr. 12	**A**	Nilosyrtis.
Apr. 17	**FA**	Thoth, Casius, Nepenthes, Nilosyrtis, Astusapes, Protonilus, Deuteronilus, and Caloe, Ismenius.
May 1	**D**	Cerberus, Styx.
May 3	**CD**	Daemon, and Phoenicis.

Mandeville, Jamaica, B. W. I.
Nov. 3, 1916.

NINETEENTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

[*Continued from page 589.*]

SPECTROGRAPHIC OBSERVATIONS OF RELATIVE MOTIONS WITHIN THE PLANETARY NEBULAE.

By W. W. Campbell and J. H. Moore.

In the past nine months, as opportunity offered, the D. O. Mills three-prism spectrograph on the 36-inch Lick telescope has been used in search for rotation effects in thirty-three planetary nebulae. Definite evidence of rotation has been observed in sixteen nebulae and suspected

in five others. In twelve nebulae no evidence of rotation was obtained, possibly because the axis of rotation in some of these may be pointing approximately toward the Earth; in which case the spectroscopic method would not be applicable.

In the nebulae which are more and more condensed as the center is approached, we seem to be dealing with simple cases of rotating bodies, with the outer strata rotating more slowly than the strata nearer the center. In other nebulae, which are of a ring form with central nuclei, rotation effects seem to be combined with other forms of motion.

The results give valuable evidence as to the probable masses of the planetary nebulae. They seem to contain sufficient material to form systems more extensive than our solar system.

The paper was illustrated with lantern slides of a few of the nebulae and their spectra.

THE SPECTRAL TYPE AND RADIAL VELOCITY OF BARNARD'S PROPER MOTION STAR.

By W. W. Campbell and J. H. Moore.

Two spectrograms, obtained with the 36-inch refractor and a single prism spectrograph with six-inch camera, show that the spectral type of this star is Mb, that its radial velocity is about -128 kilometers per second, and that it is a "dwarf" star, according to Adams' spectral test, comparatively close to us.

PECULIAR SPECTRA FOUND IN PREPARING THE NEW DRAPER CATALOGUE.

By Annie J. Cannon.

The spectroscopic survey of the entire sky for the formation of the New Draper Catalogue has resulted in the classification of 241,179 spectra, representing about 218,000 stars. The limiting magnitude for stars photographed at Cambridge is 8.5, for those taken at Arequipa, 9.0. Much time has been given of late to the re-examination and critical study of peculiar objects. It appears that less than one-fifth of one percent of these 241,000 spectra fall outside of the adopted classes known as B, A, F, G, K, M. But there are many peculiar spectra even among those which in general characteristics may be classed in one of these divisions.

Stars of the helium type having bright hydrogen lines form an interesting division of Class B. Twenty new ones have been found in this survey, besides numerous others in which $H\beta$ is so extremely faint and ill-defined that $H\alpha$ will probably prove to be bright.

Variable stars whose spectra are of class M generally have bright hydrogen lines at maximum. Three hundred and seventy-one of this class, called Md, were known before this survey, of which eighty-five were found, besides eleven new ones.

One hundred and thirty-four spectra which contain lines of two distinct classes have been observed whereas only thirty-three were known before. About one quarter of these are known to be double, either visually or spectroscopically. The others would form objects of interest for observations of velocity by means of a slit spectrograph.

In all classes of stellar spectra some stars have been found which show well marked lines of peculiar intensity. Thus in 1900, in *H. A.* **28**, 143, attention was called to a group of stars having the silicon lines at λ 4128 and λ 4131 stronger than normal, and to peculiar stars in various divisions from A2 to G0, having the strontium line λ 4077 very well marked. In 1908, *H. A.* **56**, 113, 114, 161, lists of these peculiar spectra were given. These lists have now been increased by several hundred. The group showing λ 4077 to be unusually strong is of interest since this was the first line whose intensity was proved to be connected with the absolute magnitudes of the stars. A line at about λ 3869 which may be the reversal of the well-known nebular line, has been found to be very strong in the star CPD −59° 3038, mag. 7.2.

By reason of discordant estimates real changes in the spectra of several stars have been found. Thus in 1895 the hydrogen lines in the spectrum of *Eta Carinae* were stronger and other bright lines were fainter than on later photographs. The spectrum of *R Scuti* changes from G5 at maximum to Mb at minimum.

Changes in the spectra of variable stars of short period were found by the writer nine years ago. In Circular 129, published May 10, 1907, it is stated that the spectrum of *TT Aquilae*, a variable of the *Eta Aquilae* class, changed from G at maximum to K at minimum. Observations for the New Draper Catalogue confirmed this change, the range observed being from G5 to K2. Also in *UX Centauri* a change from F2 to G5 was found. Photographs showing these changes were exhibited, also enlargements of photographs of *Delta Cephei* taken October 11 and October 12, 1907, in which, as stated in *H. A.* **56**, 110, the hydrogen lines were stronger on October 12. On the latter date the star was near maximum.

The only new type of spectrum which has been found is that of a very red star BD + 43°53. Its spectrum consists entirely of light near the region of H_α. Photographs were shown of the spectrum of this star compared with those of Class A and Class K, and of its difference in brightness when photographed with blue and yellow light. Its color index is at least 5.4 magnitudes. This star and *S Cephei*, which has a similar spectrum, are the two reddest stars known at the present time.

THE SPECTROSCOPIC BINARY γ LYRAE.

By Clifford C. Crump.

The variable velocity of γ *Lyrae* was detected in 1909 by S. A. Mitchell from studies of the Yerkes Observatory spectrograms. He found that the lines appeared "suspiciously double" on some plates and concluded that the period was about 25.6 days. Measures of the plates by C. P. Olivier and others gave discordant results perhaps due to the overlapping of lines.

Professor Guthnick at the suggestion of Professor Frost has had the star under observation with his photo-electric photometer as one of a number of stars of early type, which show difficult or peculiar variation of spectra. Coöperating with Professor Guthnick, Professor Frost placed the star on the program for continuous observation during certain nights of the summer of 1916.

Study of these plates shows many lines double in certain instances and indicates a short period, probably of only a few hours. Data communicated by Professor Guthnick indicate a period of light variation between three and four hours. He states however that a constant period has not been found which will combine series of observations taken a few months apart.

Observations of the star are being continued.

FORMS OF PLANETARY NEBULAE.

By Heber D. Curtis.

The forms of fifty planetary nebulae have been studied on photographs made with the Crossley Reflector, using various lengths of exposure times in order to get the structural detail of the very bright central portions as well as the fainter outlying parts. The majority of the planetary nebulae show a more or less regular ring or shell structure, generally with a central star. Lantern slides were exhibited showing the various types observed.

ON THE WIDTHS OF HYDROGEN EMISSION LINES IN CLASS B SPECTRA.

By R. H. Curtiss.

The outer edge of the emission components of the hydrogen lines in certain class B spectra, flanked as they are by absorption, present fairly sharp features for measurement with single-prism dispersion. Thus determinations of the widths of such emission lines become possible.

These measured widths, when corrected for slit-width and diffraction by subtracting the measured widths of neighboring essentially monochromatic comparison lines, probably represent well the actual widths of these lines.

Data of this kind for ten stars, observing in the photographic region of the spectra indicate: (1) that there is a simple linear relation $\Delta\lambda = a\ (\lambda - \lambda_o)$, between wave-lengths and line widths for the hydrogen emission lines for any spectrum of this class; (2) that the slope of the line representing this relation increases as the width of the Hβ line increases; (3) that for an Hβ line width of approximately 3.25Å, the $\Delta\lambda$'s do not change with wave-length but for smaller values of the width of the Hβ line they decrease with increasing wave-length and for larger values they increase.

The explanation is suggested that the widths of these lines are due to two principal causes, vapor density or pressure and Doppler effects attributable to atmospheric currents and rotation. The Doppler effect which probably never produces great widening is a strong factor in the cases of narrow lines and tends to produce increased widening with decreasing wave-length with an approximately linear relation for short regions of the spectrum. In the wide lines vapor density and pressure are the predominating widening agencies and are more effective with increasing wave-length.

SOME STRUCTURE VARIATIONS IN HYDROGEN EMISSION LINES IN SPECTRA OF CLASS B.

By R. H. Curtiss.

One hundred and twenty Class B to Class F spectra have been observed to show emission lines of hydrogen bright enough to be recognized. All but four of these are included in the spectral classes B0 to A0. In general the lines of hydrogen in which emission is visible in these spectra have a characteristic structure consisting frequently of a relatively narrow central dark line with emission on either side of it. This emission is flanked on either side by wide diffuse absorption borders. In many cases, especially when the emission line is narrow, the central absorption is not visible, but the absorption borders are quite characteristic. The best interpretation of these features appears to be that a very wide absorption band produced in the lowest layers of the star's atmosphere is reversed by the emission of an extensive chromospheric layer and doubly reversed by the absorption of the outer atmospheric layer.

There are ten of these spectra in which line variations appear to be established. So far as our present knowledge goes these variations are

probably of two classes: periodic, probably connected with close stellar systems, typified by β *Lyrae* and ϕ *Persei*, and progressive as typified by the fading of bright D3 in γ *Cassiopeiae* and the disappearance of bright Hγ, Hβ, and Hα in Pleione.

The emission lines of hydrogen in HR 985 and b^2 *Cygni* have been observed at Ann Arbor to change in a manner not yet fully understood. The variation consists in a change in the relative intensity of the two parts into which the emission line is divided by the central absorption. On spectrograms of HR 985 covering 49 days in 1912 the part of greater wave-length was distinctly stronger, while during 75 days in 1916 these relative intensities were strongly reversed. In the meantime between 1912 and 1916 the spectrum lines, both emission and absorption with the exception of the K line, were displaced about 45 km in the direction of greater wave-lengths. The facts suggest a long period variation associated with binary motion but the cause of such variation is very obscure. Similar line variations have been found in b^2 *Cygni* between 1911-12 and 1916.

A line variation of the progressive type is probably found in the case of ^{1} *Cygni*. In 1904 the lines Hζ to Hβ were observed to be bright at Harvard. In 1911, as observed at Ann Arbor, Hζ, Hϵ, and Hδ were strong absorption lines. Hγ possessed an emission component of the same brightness as the neighboring continuous spectrum, that of Hβ was slightly brighter. In plates of 1912, 1915, and 1916, little or no trace of the emission remained in any hydrogen line in the photographic region while the central absorption had increased at least twofold in intensity. In the meantime there was a change of over 30 km in the position of the central absorption, due probably to unsymmetrical broadening. This variation of the emission lines in f^1 *Cygni* seems to indicate that an extensive atmosphere is not a sufficient cause for the production of emisson lines of hydrogen in Class B spectra.

THE EFFECT OF HAZE SPECTRUM ON SPECTROSCOPIC DETERMINATIONS OF THE SOLAR ROTATION.

By Ralph E. De Lury.

That the overlapping sky spectrum might be strong enough to lessen the rotational displacements of the spectrum lines from the limb of the Sun, was pointed out by Halm (Edinburgh, 1901-6), who consequently made observations on the clearest days. Observers of the solar rotation since then have tried to heed the warning. Measurements made by the writer in 1911 showed that when the sky is very clear there is very little lessening of the rotational displacements by the overlapping sky spectrum. Measurements in 1912 of limb and centre spectra blended

in varying proportions showed a progressive lessening of the rotational displacements with decrease in intensity of the spectrum lines, due, of course, to the progressive increase of the ratio, (intensity of line, centre) : (intensity of line, limb), with decrease in intensity of the spectrum lines. Haze spectrum, which derives its character chiefly from the central part of the solar disc, will produce a similar *differential* effect when blended with limb spectrum, the amount of lessening of the rotational displacement depending on the relative intensities of the line in haze and limb spectra. The following results of measurements of the equatorial velocity of the solar rotation exhibit such an effect, which is consequently explainable as due to the presence of haze between the observer and the Sun, probably mostly in the terrestrial atmosphere as indicated by the Ottawa observations made on days of varying intensity of haze:

MOUNT WILSON, 1906-8. (ADAMS AND LASBY).

	km/sec.
Reversing layer, mean of a number of weak lines, λ 4250,	2.06
λ 4227,	2.12
Hα at limb,	2.12
Hα 3 mm inside limb,	2.11

These results were explained by Adams as due to increase in velocity with increase in level in the solar atmosphere.

MOUNT WILSON, 1915, λ 5200. (ST. JOHN, ADAMS, AND WARE).

					Mean
Intensity of lines	1	2	4.9	22	6.4
No. of lines	2	5	9	3	19
Velocity, km/sec.	1.924	1.933	1.945	2.043	1.950

These results were given in support of Adams' level hypothesis.

OTTAWA, 1915-6, λ 5200. (DE LURY).

					Mean	
Intensity of lines	1	2	5.3	22	5.3	
No. of lines	3	11	7	3	24	
March 11, 1916, very slightly hazy.			1.956	1.972	1.972	1.968 1.967 km/sec.
June 16, 1915, slightly hazy.			1.808	1.842	1.845	1.883 1.843 km/sec.
March 3, 1916, very hazy, haze varying.			1.738	1.760	1.814	1.887 1.816 km/sec.

These results show that as the haze increases in intensity, the value of the velocity of the solar rotation for a given line or group of lines decreases, and the difference between the values for weak and strong lines increases.

After due allowance is made for the personal and instrumental errors which are liable to be present, there will still be considerable variation in the measurements of the solar rotation by different observers depending on the degree of intensity of the scattered light from

haze or optical surfaces, on the region of the spectrum and on the selection of lines. Strong lines in the red part of the spectrum should yield values most free from the effect of scattered light. (Duner and Halm obtained exceptionally large values for observations at λ 6300).

If results of observations made during various degrees of haziness be plotted with *Velocities* as ordinates and degrees of *Haziness*, (or what may be considered a function of haziness and therefore a rough measure of it, namely, *Difference in Velocity* between weak and strong lines) as abscissae, the asymptote to the resulting curve will cut the velocity axis at the value freed from the effect of scattered light. Such a curve may be plotted for each line or for the mean. A large series of observations, in which a sufficient range of degrees of haziness is represented, thus contains the means of eliminating the effect of haze for any line or group of lines, if it be assumed that the solar rotation is constant during the period of the observations. Some series of observations, in which the effect of haze is supposed to be small, indicate a negative difference between the values of velocity for weak and strong lines, thus pointing to the possibility of a decrease in angular velocity with increase in level in the solar atmosphere, a conclusion which is the reverse of that of Adams. In general, values of the solar rotation observed during the last three years are smaller than those obtained during 1910-13; this is probably due to the fact that in general the terrestrial atmosphere has been getting hazier as a result of increased ionization accompanying increased spottedness of the Sun. All constants of the formulae derived for the solar rotation are of course affected by the presence of the spectrum of scattered light. It seems quite probable that the velocity of the solar rotation will be found invariable when the effect of scattered light is eliminated. It is scarcely necessary to add that the spectrum of scattered light affects differentially all measurements of wave-length and character of solar spectrum lines, and that the measurements of the differences between centre and limb spectra and of the displacements in the penumbra of spots are liable to be profoundly affected.

NOTE ON A SUPPOSED VARIATION IN THE SOLAR ROTATION.

By Ralph E. De Lury.

In the *Astrophysical Journal*, March 1916, is published a paper by H. H. Plaskett, entitled, "A Variation in the Solar Rotation", in which the conclusion is reached "that the Sun, during the summer of 1915, underwent a cyclic variation in its rotation rate with a range of 0.15 km. This variation was completed in about a month." Sample

results from observations made during the period in question on days of different degrees of haziness and from lines of different intensity are given in the following table.

	July 13, hazy	July 20, bright
H. H. Plaskett's values for five lines of intensities 3 to 8, λ 5900,	1.846 km/sec.	2.026 km/sec.
De Lury's values		
4225.6, Fe, 3	1.712	1.966
4226.9, Ca, 20	1.794	1.983
4232.8, Fe, 2	1.711	1.972
Difference between Ca lines and Fe lines	0.082	0.014

Thus the variation in question is due to the variation in terrestrial haze.

AN EXTENSION OF BURNHAM'S GENERAL CATALOGUE OF DOUBLE STARS.

By Eric Doolittle.

Ten years ago, some 13,665 double stars had been discovered. At this time a great "General Catalogue" in two volumes was published by Mr. S. W. Burnham, who is the highest living authority on this branch of astronomy. This catalogue contained a description of the position of each one of these objects in the sky, with reference to all measures ever made upon it, and a critical discussion of each case, telling which pairs were known to be actually two suns revolving about one another, which were merely drifting past one another, and on which ones the evidence was not yet sufficient to enable us to determine what the true nature of the system is. The work was a very complete, an almost an exhaustive one. The present paper tells of the labor, undertaken at the Flower Observatory some six years ago, of bringing this catalogue up to date. Since it appeared, some 8,000 new pairs have been discovered and a great number of new observations have accumulated from the continuous measures made at many of the leading observatories of the world. The inclusion of this material and its discussion is perhaps two-thirds completed, but the entire completion of the extension of the General Catalogue will probably require about two years more.

FIRST RESULTS ON THE DEARBORN OBSERVATORY PARALLAX PROGRAM.

By Philip Fox.

Photographic observations for the determination of stellar parallaxes were begun at the Dearborn Observatory in 1913. At the present time series of plates have been completed on about forty fields and perhaps as many more fields lack observations at but a single epoch. Meas-

urement has been delayed on account of early difficulties with the measuring machine and its later employment for other purposes. Now however two fields have been measured and reduced and the results are presented to indicate what degree of accuracy may be expected from the Dearborn Observatory plates.

Star	Relative Parallax	Probable Error	Proper Motion	Probable Error	No. of Plates	No. of Comp. Stars
BD 45° (4408) A	+0".062	±0".005	0".897	±0".008	15	8
OΣ 487 B	+0.086	0.012	0.849	0.018		
C	+0.079	0.012	0.874	0.018		
BD 32° (356)	−0.007	0.004	0.013	0.012	12	8

The star OΣ 477 C is the star noted by Furuhjelm in *A. N.* 4642 as having proper motion equal and parallel to the bright pair.

REPSOLD FILAR MICROMETER, CONSTRUCTED FOR THE 26-INCH EQUATORIAL OF THE NAVAL OBSERVATORY.

By Asaph Hall.

The arrangement of parts is in general the same as shown in Ambronn's *Handbuch der Astronomischen Instrumentenkunde*, Band II, s. 529.

This micrometer is made of iron and steel, with a platinum position circle. The micrometer screw is mounted on one side of the box, with the box screw diagonally opposite the micrometer head. The spring against which the micrometer screw works is on a slide rod parallel to the screw, and presses the end of it against a jewel mounted on a cylindrical plug. The plug can be changed by one-half a revolution, so as to eliminate periodic errors in taking coincidences.

The micrometer screw has a pitch of about 0.04 inches, equivalent to twenty one seconds, approximately. The screw can be read by the usual micrometer heads, or the readings can be printed on a Morse fillet from two type metal wheels which have on them raised figures.

All the micrometer heads, except the printing wheels, are of celluloid, which gives the desired dull surface without a reflection.

The printing wheels are parallel to the other two usual micrometer heads, and move about the micrometer screw as a center, but are fastened to a shoulder that is attached to the micrometer box, so that the printing is done without putting pressure on the screw.

For investigating the micrometer screw the makers have provided a microscope which is attached in place of the eye-piece, together with

a suitable arrangement of auxiliary spider lines placed on the movable slide. Thus, the screw can be examined with the micrometer on the instrument. Investigation by this method shows the screw to be an excellent one.

The position circle is approximately 16 inches in diameter, and is divided to 0°.1. It is read by two small microscopes, usually by estimation to 0°.01. If necessary it can be read by the microscopes to 0°.0001. This last reading is ten times more accurate than called for in the specifications drawn by the Naval Observatory, and means, it is supposed, that the circle was copied accurately from the good Repsold original circle. In addition to the fine tangent motion in position angle, there is a large hand ring for rough motion. One small electric light illuminates the two microscopes by which the position circle is read. A second lamp in parallel with this furnishes the bright wire illumination.

On the micrometer is a small crushed carbon rheostat for varying the brightness of the wires. The color of the wires can be changed by the use of different color screens which can be placed about the lamp which furnishes illumination. The current for the lamps comes down the instrument and through contact rings on the micrometer. Extreme care is taken to make the lighting of the threads symmetrical. The bright field illumination has not been changed. That is, light is thrown against the object glass from a small electric lamp mounted inside the tube, near the eye end, just out of the cone of rays. This light comes back from the object glass and gives the bright field.

The eye-piece has a double slide. Therefore, parallels can be taken on the long wires, in which case the star is placed on the wire by means of the slow motion in declination, or the short wires can be used and the star set accurately on one of them by the box screw.

The tail-piece for attaching the new micrometer to the instrument was constructed at the Washington Navy Yard.

THE VARIABLE NEBULA N. G. C. 2261.

By Edwin P. Hubble.

Photographs of N.G.C. 2261, whose nucleus is known as the variable star *R Monocerotis* indicate that pronounced changes occurred in the nebula between March, 1908 and January, 1913. A new feature appeared in the south following portion, and a small stellar mass just south following the nucleus moved in toward the nucleus some 2″.7. No great changes have occurred since. The nebula gives a continuous spectrum and lies in a dark region of the sky connected with the nebulosity around 15 *Monocerotis*.

IRREGULARITIES IN REFRACTION.

By Charles J. Hudson.

In *Allegheny Publications* Vol. 3, No. 1, Dr. Schlesinger confirmed the results of Nusl and Fric in which they showed that there are irregularities in atmospheric refraction with a period of about one minute and an amplitude of about one second of arc.*

For Dr. Schlesinger's experiment some star trails taken with a long focus, stationary, camera were required. As the Thaw telescope was not completed at that time, plates were taken for him with the Yerkes telescope and also with the Mt. Wilson sixty-inch reflector. Trails of the Pleiades with each of these instruments showed that the irregularities occurred simultaneously in stars as far apart as twenty minutes of arc.

In the present experiment an attempt was made to locate the cause of the disturbance.

First, two photographic lenses of seventeen feet focal length were mounted in the meridian so that a star would trail on their plates at the same time. Upon measuring the plates the irregularities were found to have occurred in each trail at the same time. This shows that the cause of the irregularities was not in the tube of the telescope for the cameras were tubeless. Second, the two cameras were so set up that two stars would trail at the same time on the plates—one on one plate and one on the other. Again the irregularities occurred at the same time, this time in stars more than a degree apart. Third, one camera was placed about two hundred feet east and about thirty feet above the other and parallel to it. When the trails were measured it was found that the irregularities did not at all occur at the same time.

The conclusion is that the cause of the irregularities in refraction is near, perhaps within the dome, but certainly not more than one or two hundred feet away.

PROGRESS IN PHOTO-ELECTRIC PHOTOMETRY.

By Jakob Kunz and Joel Stebbins.

During the past year we have made various advances in the production of photo-electric photometers. Some of the disturbing factors, such as dark current, are due to the glass wall of a cell, and by using quartz instead of glass much of the trouble is eliminated.

* See *Publications of A. A. S.* Vol. 2, 109.

PRELIMINARY MEASURES OF THE SPIRAL NEBULAE N. G. C. 5194 (M 51) AND N. G. C. 4254 (M 99) FOR PROPER MOTION AND ROTATION.

By C. O. Lampland.

The positions of a number of nebulous condensations and nuclei, and stars in the nebulosity and in the immediate vicinity of the spiral nebula N. G. C. 5194 and 4254 were measured by Sir Isaac Roberts on negatives made in 1896 and 1898 with his 20-inch reflector. It was thought worth while to remeasure these positions on negatives made with the 40-inch reflector of the Lowell Observatory, in 1915 and 1916. There are, of course, disadvantages and uncertainties in comparisons of difficult observations of this kind made by different observers from measurements of negatives made with instruments of greatly different focal lengths.

In M 51 Roberts measured 81 points—condensations and nuclei in the nebulous matter, and stars in the nebulosity and near the nebula. After making corrections for the derived value of the motion of the nucleus the residuals for some of the positions are larger than one might judge to be due to uncertainties in the measurements but at present it is a difficult and somewhat uncertain matter to determine how much of this may be due to accidental and systematic errors of observation or to actual changes that may have taken place during the interval between the two series of photographs—eighteen years. For a number of these points, small and well-defined nuclei and nebulous masses, there appears to be evidence of motion, both in position angle and distance, relative to the nucleus. Motion is indicated for several of the small stars in the nebulosity and near the nebula. The yearly proper motion of the central nucleus from a comparison of the two series of photographic measures (Roberts 1898, Lampland 1915, 1916)—making use of twenty comparison stars, assuming that these are not physically connected with the nebula—comes out $+ 0''.118$ in right ascension and $- 0''.017$ in declination. From seven observations of position by earlier observers the resulting values for the components of motion in right ascension and declination are respectively $+ 0''.118$ and $- 0''.007$. But the observations of position are discordant and not much emphasis should be placed on the satisfactory agreement between the values for motion derived from them as compared with the value found from the photographic observations. From direct comparison in position angle of the photographic observations (1898-1915, 1916) the angular motion of the second nucleus, N. G. C. 5195, relative to the central nucleus is approximately $30''$ per year clockwise, or in the direction of decreasing position angle. (It will be remembered that the nebula is a left hand spiral). The differences of the proper

motions of the two nuclei as derived from the photographic observations give an angular motion of about 27″ per year clockwise. The positions of the nuclei have been measured by many observers and, from the determinations at present accessible, values for the rotation ranging from 12″ to 20″ per year clockwise were found. The angular motions mentioned would correspond to periods in years as follows: 43000, 48000, 65000, 108000. From the observational data at hand there appears to be no trustworthy indication of a change in distance between the two nuclei. It is hoped that more observational material, earlier photographs, will shortly be available for measurement to decide definitely if possible the questions raised in this comparison of observations.

Measures of several negatives of N. G. C. 4254 (M 99) made with the 40-inch reflector in 1915 and 1916 were compared with the earlier observations by Roberts. Residuals in position angle and distance, for the comparison stars used, agree in indicating a large proper motion for the nucleus, approximately 1/3″ yearly on a great circle in position angle 42°. So large a value must immediately arouse suspicion as to its reality. The different measures of the negatives with the 40-inch reflector are concordant. It is possible that the large value for the motion might be due to systematic errors in the earlier observations. From observations of position of the nucleus by earlier observers and from measures of negatives with the 40-inch reflector, with epochs of observation extending from 1868 to 1916, the resulting components of motion are approximately + 0″.016 in right ascension and + 0″.043 in declination. The residuals for many of the nebulous condensations, from the photographic observations of 1896, 1915 and 1916, are large. More observational material will be needed to decide the question of possible motion of the nebulous condensations relative to the nucleus.

THE ECLIPSING VARIABLE SS CAMELOPARDALIS.

By R. J. McDiarmid.

The variable star SS Camelopardalis was discovered by Miss A. J. Cannon of Harvard, with a photographic range of 1.2 magnitude, 9.8 to 11.0.

10,992 photographic measures (16 measures to an observation) were made with a polarizing photometer attached to the 23-inch equatorial of the Princeton Observatory. The observations are best satisfied by the following light elements.

$$\text{J.D. } 2{,}420{,}842.594 + 4^d.82438 = 1915 \text{ Dec. } 10^d\ 14^h\ 21^m \text{ G.M.T.}$$
$$+ 4^d\ 19^h\ 47^m - 6^s.4.$$

Epoch taken from the middle of primary minimum.

There are two distinct eclipses, primary and secondary. The visual range from maximum to primary minimum is 0.57 magnitude and to

secondary minimum, 0.15 magnitude. The stars are ellipsoidal and when correction is made for this, the depths of the minima become 0.485 and 0.082 magnitude respectively. The brightness is greater by about 0.05 magnitude half way between secondary and primary than between primary and secondary. The principal eclipse lasts twenty-one hours and is total for seven hours; the secondary is annular.

The system consists of a large red star of low surface brightness and a smaller white star a little more than one third the diameter of the other, but of five times the surface brightness of the larger star, visually, and twelve times the surface brightness photographically, so that the smaller star is visually the fainter and photographically the brighter of the two.

The density of the large red star is about one two-hundredths and that of the small white star is one-twelfth that of the Sun. The combined spectra is recorded as F?. It is not improbable that the small star is of spectrum A and the larger of spectrum G or redder.

The following table contains the results from the uniform and "darkened" solutions.

TABLE RESULTS.

Elements of System		Uniform	Darkened
Maximum radius of small star	a_2	0.150	0.153
Minimum radius of small star	b_2	0.136	0.144
Maximum radius of large star	a_1	0.446	0.444
Minimum radius of large star	b_1	0.406	0.417
Ratio of the radii of the two stars	k	0.335	0.345
Ratio of the axes of the spheroidal stars	$1+\frac{1}{2}z$	1.038	1.054
The least apparent distance of centres	$\cos i$	0.2024	0.2305
Inclination of orbit	i	78°.3	76°.0
Eccentricity or orbit	$e\cos\omega$	−0.03	
Maximum percentage loss of light at primary minimum	α_{op}	1.00	1.00
Maximum percentage loss of light at secondary minimum	α_{os}	1.00	*1.096
The light of the bright star ⎫ visual	L_b	0.6397	0.6397
The light of the faint star ⎭ visual	L_f	0.3603	0.3603
Ratio of the surface brightness of the two stars (visual)	$\frac{J_b}{J_f}$	5.02	4.74
The light of bright star ⎫ photographic	L_b	0.583	
The light of faint star ⎭ photographic	L_f	0.417	
Ratio of surface brightness of the two stars (photographic)	$\frac{J_b}{J_f}$	12.2	11.7
Most probable density of smaller star	ρ_b	0.094	0.078
Most probable density of larger star	ρ_f	0.0050	0.0046
Hypothetical radius of brighter star in terms of solar radius		2.32	2.32
Hypothetical parallax			0.0009
Distance in light years from the galactic plane			1700
Distance in light years projected on galactic plane			3200
Visual magnitude of system			10.15
Visual magnitude of big star End on			10.65
Visual magnitude of small star End on			11.26
Photographic magnitude of system			9.9
Photographic magnitude of big star End on			10.86
Photographic magnitude of small star End on			10.48

* Expressed in terms of the light lost at internal tangency.

SUMMARY OF THE SPROUL OBSERVATORY PARALLAX WORK,

By John A. Miller.

The paper was a resumé of the work done at Sproul Observatory on Stellar Parallax. The parallax of sixty-four objects has been determined. Twenty of these are visual binaries whose orbits are well determined. Five are spectroscopic binaries. One, ϵ *Hydrae*, is a spectroscopic and a visual binary. The remainder are nearly equally distributed among stars whose hypothetical parallax is large, stars of large proper motion, and stars with two or more discordant determinations. The average of probable error of all the determinations is about 0.010. The results for 42 objects are given here, the visual binaries are discussed in the paper by Miss Steele.

Star	R. A. h m	Decl. ° ′	π ″	″
ϵ Andromedae	0 33.3	+28 46	+0.096	±0.015
μ Andromeda	0 51.2	+37 57	+0.032	±0.013
θ Cassiopeiae	1 5.0	+54 37	−0.003	±0.003
Σ 228	2 7.6	+47 1	+0.069	±0.009
ι Persei	3 1.8	+49 14	+0.120	±0.012
Greenwich 284	3 56.5	+35 2	+0.072	±0.002
0Σ (App.) 54	4 36.2	+22 46	−0.053	±0.009
τ Tauri	4 36.2	+22 46	+0.012	±0.013
Weisse 4^h, 1189	4 55.9	− 5 52	+0.111	±0.019
λ Aurigae	5 12.1	+40 1	+0.069	±0.008
BD −3° 1118	5 26.4	−3 42	−0.020	±0.018
ϕ_2 Orionis	5 31.4	+9 15	+0.027	±0.006
0Σ 149	6 30.2	+27 22	+0.048	±0.013
Lalande 13198	6 45.7	− 0 25	+0.015	±0.008
Nova Gemin. No. 2, 1912	6 49.3	+32 15	−0.019	±0.035
ζ Geminorum	6 58.1	+20 41.8	+0.017	±0.019
Lalande 13849	7 4.2	+21 25	+0.019	±0.010
Procyon	7 34.1	+ 5 29	+0.287	±0.012
13 Canis Minoris	7 57.1	+ 2 36	+0.035	±0.008
β 581	7 58.8	+12 35	+0.082	±0.009
Lalande 16304	8 13.7	−12 18	+0.075	±0.007
10 Ursae Majoris	8 54.2	+42 11	+0.086	±0.015
11 Leonis Minoris	9 29.7	+36 16	+0.220	±0.022
Bradley 1433	10 16	+41 44	+0.080	±0.007
36 Ursae Majoris	10 24	+56 30	+0.090	±0.013
Lalande 21185	10 57.9	+36 38	+0.443	±0.010
β Leonis	11 44	+15 8	+0.116	±0.013
33 Virginis	12 41.3	+10 6	−0.003	±0.008
μ Bootis	15 20.7	+37 44	+0.033	±0.029
Σ 2107	16 48	+28 50	+0.006	±0.006
u Herculis	17 13.6	+33 12	−0.031	±0.007
26 Draconis	17 34	+61 58	+0.080	±0.016
δ Cygni	19 41.9	+44 56	+0.049	±0.008
BD 44° 3242	19 42.8	+44 51.8	−0.012	±0.007
X Cygni	20 39.5	+35 14	+0.000	±0.008
61 Cygni	21 2.4	+38 15	+0.301	±0.022
	21 25.4	+45 1.9	−0.006	±0.009
g Cygni	21 25.8	+46 6	+0.027	±0.008
	21 26.8	+46 5.7	+0.002	±0.027
ι Pegasi	22 2.4	+24 51	+0.063	±0.011
ϵ Cephei	22 11.3	+56 33	+0.30	±0.008
Bradley 3077	23 8.5	+56 37	+0.181	±0.009

(*To be continued.*)

PLANET NOTES FOR JANUARY, 1917.

The sun will move northward 5° during the month, from — 23° to — 17°. It will move in an easterly direction from the constellation of Sagittarius into Capricornus through a region in which there are no particularly bright stars. A partial eclipse of the sun will occur on January 22. It will not be visible in the western hemisphere. There will be a total eclipse of the moon January 7. The data are as follows:

		h	m		
Moon enters penumbra	January 7 at	10	35.7	P.M.	C.S.T.
Moon enters shadow	7 "	11	50.4	P.M.	"
Total eclipse begins	8 "	1	0.4	A.M.	"
Middle of eclipse	8 "	1	44.6	A.M.	"
Total eclipse ends	8 "	2	28.8	A.M.	"

THE CONSTELLATIONS AT 9:00 P. M. JANUARY 1.

The phases of the moon for January are as follows:

		h	m		
Full Moon	January 8 at	1	42	A.M.	C.S.T.
Last Quarter	15 "	5	42	A.M.	"
New Moon	22 "	1	40	A.M.	"
First Quarter	29 "	7	2	P.M.	"

Mercury will reach a point of greatest elongation on January 2. On the sixteenth of the month its stellar magnitude will be + 2.1. At this time it may be seen in the twilight about 4° north of where the sun sets. It will be found in the constellation Sagittarius.

Venus may be seen in the morning sky in the constellation Ophiuchus.

Mars will not be visible during the month.

Jupiter will still be in a position for evening observation. It will have a westward motion in the constellation Pisces.

Saturn will be on the meridian at midnight on the fifteenth of the month. At the beginning of the month it will be found near the western boundary of Cancer.

Uranus will not be visible.

Neptune at the beginning of the month may be found with the aid of a smal telescope about 30m east of Saturn near the eastern boundary of Gemini.

Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME.

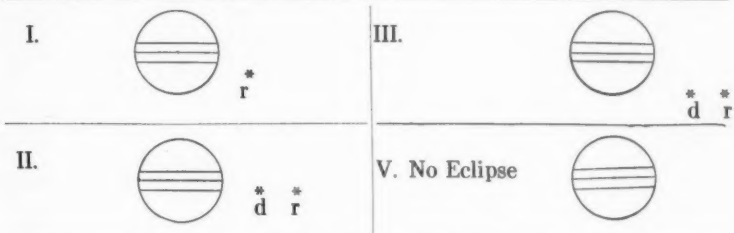
1917	h	m				h	m		
Jan. 1	5	7	II	Ec. R.	Jan. 16	4	41	III	Sh. I.
2	11	34	I	Tr. I.		6	20	III	Sh. E.
3	8	53	I	Oc. D	17	5	29	II	Sh. E.
4	6	2	I	Tr. I.	18	9	52	I	Tr. I.
	7	20	I	Sh. I.	19	7	11	I	Oc. D.
	8	12	I	Tr. E.		10	43	I	Ec. R.
	9	29	I	Sh. E.	20	5	41	I	Sh. I.
5	5	4	III	Oc. D.		6	30	I	Tr. E.
	6	51	I	Ec. R.		7	49	I	Sh. E.
	7	4	III	Oc. R.	21	5	12	I	Ec. R.
	10	33	III	Ec. D.	22	7	43	II	Oc. D.
6	8	22	II	Tr. I.		10	20	II	Oc. R.
	10	56	II	Tr. E.		10	26	II	Ec. D.
	11	2	II	Sh. I.	23	5	8	III	Tr. E.
8	5	6	II	Oc. R.		8	44	III	Sh. I.
	5	11	II	Ec. D.		10	22	III	Sh. E.
	7	44	II	Ec. R.	24	5	29	II	Tr. E.
10	10	47	I	Oc. D.		5	36	II	Sh. I.
11	7	57	I	Tr. I.		8	7	II	Sh. E.
	9	16	I	Sh. I.	26	9	8	I	Oc. D.
	10	6	I	Tr. E.	27	6	17	I	Tr. I.
12	5	16	I	Oc. D.		7	36	I	Sh. I.
	8	47	I	Ec. R.		8	27	I	Tr. E.
	9	0	III	Oc. D.		9	45	I	Sh. E.
	11	2	III	Oc. R.		7	7	I	Ec. R.
13	5	54	I	Sh. E.	29	10	22	II	Oc. D.
	10	56	II	Tr. I.	30	6	13	III	Tr. I.
15	5	5	II	Oc. D.		9	16	III	Tr. E.
	7	42	II	Oc. R.	31	5	35	II	Tr. I.
	7	49	II	Ec. D.		8	10	II	Tr. E.
	10	21	II	Ec. R.		8	14	II	Sh. I.

Note:—I., denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Satellites of Jupiter, January, 1917.

GREENWICH MEAN TIME.

Phases of the Eclipses of the Satellites for an Inverting Telescope.



Configurations at 14h 10m for an Inverting Telescope.

Day	West	East
1	4· ·1 ○ 3:2	
2	·4 3· ○ 1· 2·	
3	·4 ·3 2· ·○1	
4	○1· ·4 ·3 ·2 ○	
5	·4 ○:3 ·1 ·2	
6	1· 2○· ·4 ·3	
7	·2 ○ ·1 ·4 3·	
8	·1 ○ ·2 3· ·4	
9	3· ○ 1· 2· ·4	
10	3· 2· ·1 ○ 4·	
11	○1· ·3 ·2 ○ 4·	
12	·○ 3 ·2 4· ·1●	
13	1· ○ 2· 4:3	
14	2· 4○· ·1 3·	
15	4· 1· ○ 3· ·2●	
16	4. 3· ○ 1· 2·	
17	4· 3· 2:1 ○	
18	4· ·3 ·2 ○1·	
19	·4 ·3 ○ ·2 ·1●	
20	·4 1· ○ 2· ·3	
21	·4 2· ○ ·1 ·3	
22	1:4 ○ 3· ·2●	
23	3· ○ 1:4 2·	
24	3· ·12· ○ ·4	
25	·3 ·2 ○ 1· ·4	
26	·3 ·○1 ·2 .4	
27	○1· ○ 2· .3 4·	
28	2· ○ ·1 ·3 4·	
29	1· ·2○ 3· 4·	
30	○3· ○ ·1 4:2	
31	○2· 3· ·1 4·○	

Occultations Visible at Washington.

Date 1917	Star's Name	Magnitude	IMMERSION. Washington M.T.		Angle from N.	EMERSION. Washington M.T.		Angle from N.	Duration	
			h	m	°	h	m	°	h	m
Jan. 3	66 Arietis	6.1	4	16	108	5	14	207	0	59
3	23 Tauri	4.3	15	06	12	15	20	345	0	13
6	5 Geminorum	5.9	4	44	152	5	09	202	0	25
7	44 Geminorum	5.9	5	21	125	6	12	240	0	50
7	δ Geminorum	3.5	14	39	106	15	53	302	1	14
7	149 B.Geminorum	6.4	18	33	45	18	56	354	0	23
7	63 Geminorum	5.3	18	55	52	19	23	346	0	28
8	85 Geminorum	5.2	5	32	91	6	29	285	0	57
8	217 B.Geminorum	6.3	8	11	57	9	03	328	0	52
9	54 Cancri	6.3	10	21	169	11	06	236	0	45
10	ξ Leonis	5.1	7	38	165	8	10	231	0	32
11	155 B. Leonis	6.5	11	59	141	13	18	286	1	19
14	*q* Virginis	5.3	10	55	88	11	47	330	0	52
18	85 B. Scorpii	6.0	15	16	71	16	05	322	0	50
26	19 Piscium	5.4	6	25	70	7	30	229	1	05
29	26 Arietis	6.2	10	37	55	11	35	283	0	58
30	66 Arietis	6.1	12	39	124	13	24	229	0	45

VARIABLE STARS.

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1917. January							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Cassiop.	0	09.8	+57	52	9.3— 9.9	4	1.7	3	16;	11	19;	19	22;	28	1
RR Ceti	1	27.0	+ 0	50	8.3— 9.0	0	13.3	3	3;	10	21;	18	15;	26	9
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2	7	2			21	21		
V Arietis	2	09.6	+11	46	8.3— 9.0	0	23.8	5	15;	13	14;	21	12;	29	11
SU Cassiop.	2	43.0	+68	28	6.5— 7.0	1	22.8	6	23;	14	19;	22	14;	30	9
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	1	2;	8	9;	22	23;	30	5
RW Camelop.	3	46.2	+58	21	8.2— 9.4	16	00.0	4				20			
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	5	16;	14	6;	22	20;	31	10
SV Persei		42.8	+42	07	8.8— 9.6	11	03.1	7	4;	18	7;	29	11		
RX Aurigae	4	54.5	+39	49	7.2— 8.1	11	15.0	4	18;	16	9;	28	0		
SX Aurigae	5	04.6	+42	02	8.0— 8.7	1	12.8	9	7;	16	23;	24	15		
SY Aurigae		05.5	+42	41	8.4— 9.5	10	03.3			10	10;	20	14;	30	17
Y Aurigae		21.5	+42	21	8.6— 9.6	3	20.6	3	7;	11	20;	18	18;	26	11
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	3	21;	14	22;	25	23;	31	12
RS Orionis	6	16.5	+14	44	8.2— 8.9	7	13.6	4	4;	11	17;	19	7;	26	20
T Monoc.		19.8	+ 7	08	5.7— 6.8	27	00.3					19	21		
RT Aurigae		23.0	+30	33	5.1— 6.0	3	17.5	8	1;	15	12;	22	23;	30	10
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	4	3;	11	8;	18	14;	25	18
W Gemin.		29.2	+15	24	6.7— 7.5	7	22.0	8	19;	16	17;	24	14		
ζ Gemin.	6	58.2	+20	43	3.7— 4.3	10	03.7	2	1;	12	5;	22	8		
RU Camelop.	7	10.9	+69	51	8.5— 9.8	12	06.5			21	0				
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	4	4;	12	2;	20	1;	28	0

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1916. January							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	4 3;	10 20;	24 5;	30 22				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	1 1;	10 7;	19 14;	28 21				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	8 2;	16 19;	25 13					
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	1 9;	8 4;	14 23;	28 13				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	6 22;	13 12;	20 3;	26 17				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	9 15;	19 7;	28 23					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	7 20;	15 19;	23 19;	31 18				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	6 10;	13 3;	19 21;	26 15				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	1 21;	13 12;	25 4;	31 0				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	2 15;	12 1;	21 10;	26 2				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5		11 4;	28 11					
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	3 19;	12 0;	20 5;	28 10				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	2 11;	9 11;	23 12;	30 13				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	1 13;	9 18;	17 23;	26 4				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	4 16;	10 14;	21 4;	26 16				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 11;	10 0;	17 13;	25 2				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	2 7;	9 17;	24 13;	31 23				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	1 22;	8 17;	22 7;	29 2				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	3 17;	10 0;	22 16;	29 0				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	3 1;	12 19;	22 13					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	5 6;	14 3;	23 0;	30 20				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	4 18;	10 19;	22 22;	28 23				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	3 10;	10 10;	24 11;	31 11				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		14 17;		31 20				
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	7 0;	14 14;	22 4;	29 18				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	2 4;	7 22;	19 12;	31 1				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	5 16;	12 9;	19 3;	25 21				
Y Scuti	18 32.6	− 8 27	8.7— 9.2	10 08.3	3 2;	13 10;	23 19					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	2 13;	8 14;	20 16;	26 16				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	6 16;	12 19;	25 2;	31 5				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	3 6;	9 5;	21 2;	27 1				
κ Pavonis	18 46.6	—67 22	3.8— 5.2	9 02.2	9 22;	19 0;	28 2					
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	3 23;	10 23;	19 0;	25 0				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	3 4;	10 4;	24 4;	31 4				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	1 16;	9 16;	17 15;	25 15				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	3 15;	11 7;	18 23;	26 16				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	6 17;	13 22;	21 2;	28 6				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	8 4;	16 14;	24 23					
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	1 5;	7 13;	20 4;	26 11				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	5 11		21 20					
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	1 15;	10 12;	19 9;	28 6				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	6 2;	13 20;	20 13;	27 6				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	5 18;	12 11;	18 4;	25 22				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		10 20;	25 14					
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	6 20;	14 16;	22 13;	30 10				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	7 13;	14 10;	21 8;	28 5				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	5 19;	10 16;	20 9;	30 2				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	2 19;	11 11;	20 2;	28 18				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	3 14;	8 23;	19 16;	30 10				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	9 23;	20 20;	31 17					
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	3 15;	10 0;	22 20;	29 6				
V Lacertae	22 44.5	+55 48	8.5— 9.5	4 23.6	2 12;	7 12;	17 11;	27 10				
X Lacertae	45.0	+55 54	8.2— 8.6	5 10.7	2 11;	7 21;	18 18;	29 16				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	1 23;	12 20;	23 17;	29 4				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1 7;	7 14;	13 21;	26 12				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4		11 8;	23 11					
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.6	1 20;	11 20;	21 19;	31 18				

Minima of Variable Stars of Short Period.

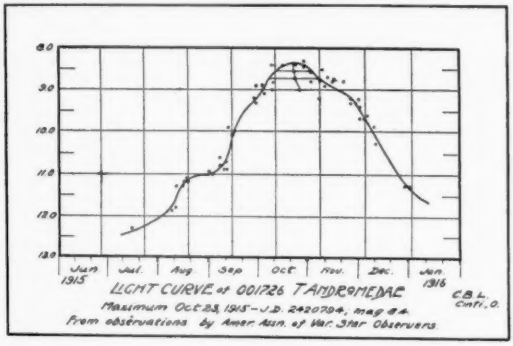
[Calculated by Lois N. Wilson at Goodsell Observatory.]

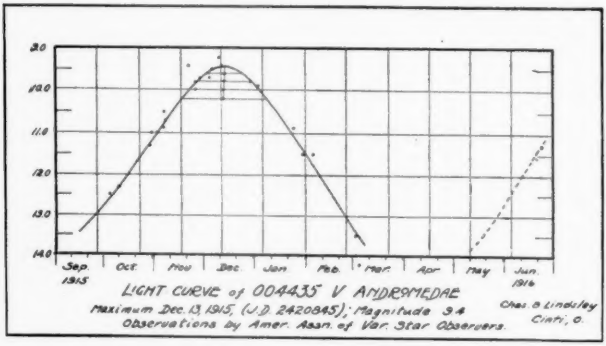
Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

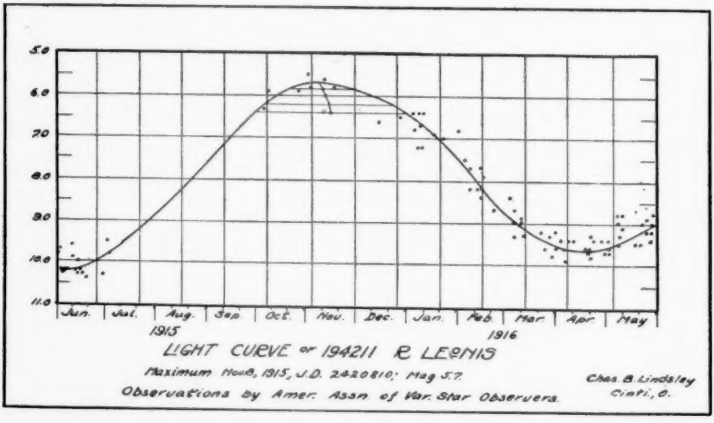
Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 January							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			23 8					
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	4 12;	12 4;	19 20;	27 12				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	10 8;	17 19;	25 5					
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	8 5;	15 16;	23 4;	30 15				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	1 3;	7 6;	13 8;	25 14				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	4 9;	11 12;	18 16;	25 19				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	7 17;	14 13;	21 10;	28 7				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	8 4;	15 19;	22 23;	30 3				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	1 1;	9 20;	18 15;	27 9				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	7 15;	15 13;	23 12;	31 11				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6				30 17				
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	3 2;	14 14;	20 7;	31 19				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	4 1;	10 20;	17 15;	31 5				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	1 3;	9 0;	16 22;	24 20				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	0 22;	9 6;	17 13;	25 20				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	5 14;	13 11;	21 9;	29 6				
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	3 10;	16 14;	29 19					
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	1 6;	10 17;	20 3;	29 14				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1		10 2;	22 12					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	2 14;	9 6;	22 14;	29 6				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	2 18;	8 5;	19 3;	27 8				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	2 16;	8 16;	20 17;	26 18				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	2 15;	11 7;	19 23;	28 15				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	2 2;	12 12;	22 22					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	5 23;	13 23;	21 23;	30 0				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	5 2;	10 19;	22 6;	28 0				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	5 5;	10 19;	22 0;	27 15				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	5 18;	13 23;	22 4;	30 8				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	4 14;	12 5;	19 20;	27 10				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0		12 20;	25 1					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	6 21;	14 1;	21 5;	28 10				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	1 22;	8 18;	22 9;	29 5				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	4 7;	13 14;	22 21					
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	2 15;	9 6;	22 11;	29 2				
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	5 10;	13 20;	22 5;	30 15				
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	4 9;	10 19;	23 16;	30 2				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	2 20;	10 2;	24 15;	31 22				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	3 18;	11 21;	20 0;	28 2				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	2 6;	11 18;	21 5;	30 17				
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	7 10;	14 7;	21 3;	27 23				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	4 15;	10 13;	22 10;	28 8				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	2 7;	9 1;	22 13;	29 7				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	4 13;	11 23;	19 9;	26 19				
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	1 17;	8 8;	21 13;	28 3				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	9 14;	18 10;	27 5					
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	8 4;	15 12;	22 20;	30 4				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	3 10;	10 5;	23 19;	30 14				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	7 22;	15 10;	22 22;	30 10				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	8 19;	18 9;	27 23					
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	4 21;	12 7;	19 18;	27 4				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	3 12;	10 11;	24 11;	31 10				

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 January
	h m	° ′		d h	d h d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	6 21; 13 18; 20 16; 27 14
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	1 7; 9 17; 18 3; 26 13
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	2 14; 10 6; 17 22; 25 13
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	1 21; 9 6; 23 22; 31 6
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	5 7; 13 13; 21 20; 30 2
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	9 3; 18 0; 26 20
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	16 15; 29 17
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	1 1; 7 21; 21 11; 28 6
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	3 3; 11 12; 19 21; 28 7
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	6 7; 12 11; 18 14; 24 18
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	2 3; 9 8; 23 18; 30 23
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	3 1; 10 10; 17 19; 25 4
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	6 20; 15 0; 23 4; 31 9
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	2 2; 9 15; 17 4; 24 17
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	4 6; 11 23; 19 17; 27 11
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	6 14; 14 13; 22 13; 30 13
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	4 20; 13 9; 21 21; 30 10
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	7 17; 17 1; 26 9
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	7 23; 18 7; 28 16
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	2 11; 9 17; 24 5; 31 10
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	4 9; 11 7; 18 5; 25 3
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	14 10 29 13
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	6 19; 13 23; 21 3; 28 7
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	7 5; 14 7; 21 10; 28 13
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	9 5; 17 13; 25 20
RR Draconis	40.8	+62 34	9.3—13	2 19.9	1 20; 10 8; 18 19; 27 7
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	1 16; 8 8; 21 15; 28 6
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	2 6; 15 4; 28 2
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	3 12; 11 3; 18 19; 26 10
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	2 23; 10 13; 18 3; 25 16
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	7 16; 14 21; 22 1; 29 6
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	4 3; 13 2; 22 1; 31 0
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	5 11; 12 5; 19 0; 25 18
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	4 17; 12 2; 19 10; 26 19
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	3 19; 9 1; 19 12; 30 0
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	3 17; 10 6; 23 7; 29 20
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	4 18; 10 18; 22 18; 28 18
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	2 7; 8 22; 22 5; 28 20
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	1 7; 10 11; 19 14; 28 18
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	9 5; 17 15; 26 2
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	2 4; 8 23; 22 12; 29 7
UW Cygni	19.6	+42 55	10.5—10.8	3 10.8	7 2; 14 0; 20 22; 27 19
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	19 12
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	6 14; 16 4; 25 19
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	3 18; 12 22; 22 3; 31 8
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	2 6; 9 18; 17 6; 24 17
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	2 5; 9 20; 17 10; 25 0
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	7 19; 17 21; 28 0
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	7 11; 14 20; 22 5; 29 15
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	9 12; 19 5; 28 21
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	6 10; 14 7; 22 3; 30 0
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	1 8; 11 11; 21 15; 31 18
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	24 6
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	5 6; 15 15; 20 20; 31 5
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	1 11; 9 18; 18 1; 26 8
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	7 7; 14 20; 22 8; 29 21
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	5 9; 13 15; 21 21; 30 3
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7	10 16


8.0
9.0
10.0
11.0
12.0
13.0
Jun. 1915
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
Jan. 1916
LIGHT CURVE of 001726 T ANDROMEDAE
Maximum Oct. 23, 1915 – J.D. 2420794, mag 8.4.
From observations by Amer. Assn. of Var. Star Observers.
C.B.L.
Cinti., O.


10.0
11.0
12.0
13.0
14.0
Sep. 1915
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun. 1916
LIGHT CURVE of 004435 V ANDROMEDAE
Maximum Dec. 13, 1915, (J.D. 2420845); Magnitude 9.4
Observations by Amer. Assn. of Var. Star Observers.
Chas. B. Lindsley
Cinti, O.


5.0
6.0
7.0
8.0
9.0
10.0
11.0
Jun.
Jul.
Aug. 1915
Sep.
Oct.
Nov.
Dec.
Jan.
Feb. 1916
Mar.
Apr.
May
LIGHT CURVE OF 194211 R LEONIS
Maximum Nov. 8, 1915, J.D. 2420810; Mag 5.7
Observations by Amer. Assn. of Var. Star Observers.
Chas. B. Lindsley
Cinti, O.

COMET AND ASTEROID NOTES.

New Comet 1916 *c* (Metcalf).—A telegram received November 24, from Harvard College Observatory, announces the discovery of a very faint comet on November 21, by Rev. Joel Metcalf of Winchester, Mass. The position given is

Nov. 21.5673 Gr.M.T. R.A. $3^h\ 38^m\ 00^s.5$, Decl. $+18°\ 32'\ 50''$.

Daily motion $11^s.5$ west and $35''.4$ south. Appearance starlike.

In the Harvard College Observatory Bulletin 618 the following approximate positions are given:

Gr.M.T		α			δ		Observer	Place
		h	m	s	°	′		
Nov.	21.5673	3	38	00.5	+ 18	32.8	Metcalf	Winchester
	22.5396	3	37	49.3	+ 17	58.4	"	"

It is also stated there that the comet is very faint, but eight photographic images have been obtained. This is the fourth comet discovered by Mr. Metcalf.

At Northfield the comet was searched for in vain, both with the 16-inch telescope and the 6-inch photographic camera, on the night of November 24.

Ephemeris of Comet *b* 1916 (Wolf).

1917 Gr.M.T.		True α			True δ			log Δ	Br.
		h	m	s	°	′	″		
Jan.	1.5	16	04	36.5	−6	04	58		
	2.5		06	29.1		05	00	0.5192	5.03
	3.5		08	22.2		04	55		
	4.5		10	15.7		04	43	0.5146	5.20
	5.5		12	09.7		04	23		
	6.5		14	04.1		03	56	0.5099	5.39
	7.5		15	58.9		03	21		
	8.5		17	54.2		02	39	0.5052	5.58
	9.5		19	49.9		01	49		
	10.5		21	46.1	−6	00	51	0.5004	5.79
	11.5		23	42.7	−5	59	45		
	12.5		25	38.8		58	31	0.4955	6.00
	13.5		27	37.3		57	09		
	14.5		29	35.3		55	39	0.4906	6.23
	15.5		31	33.7		54	00		
	16.5		33	32.5		52	13	0.4856	6.46
	17.5		35	31.8		50	17		
	18.5		37	31.5		48	13	0.4806	6.71
	19.5		39	31.6		46	00		
	20.5		41	32.2		43	37	0.4754	6.96
	21.5		43	33.2		41	06		
	22.5		45	34.6		38	25	0.4702	7.23
	23.5		47	36.4		35	36		
	24.5		49	38.7		32	37	0.4650	7.51
	25.5		51	41.4		29	29		
	26.5		53	44.5		26	12	0.4597	7.81
	27.5		55	48.0		22	45		
	28.5		57	51.9		19	08	0.4543	8.12
	29.5	16	59	56.2		15	22		
	30.5	17	02	01.0		11	26	0.4489	8.44
Jan.	31.5	17	04	06.2	−5	07	20		

Encke's Comet.—The observation of Encke's comet to which we referred in our October issue, p. 546, appears to have been a pair of photographs by Wolf, at Heidelberg, which gave the position of the comet as

1916 Sept. 22 $9^h\ 6^m.6$ Gr.M.T. R.A. $22^h\ 28^m\ 39^s.0$ Decl. $-7°\ 08'\ 05''$

The comet appeared as a small nebula of the 16th magnitude, with a slight condensation. The motion between two exposures agreed with the ephemeris. The comet had passed aphelion only one month earlier and it is therefore hardly proper to label this observation as made at a "return of Encke's comet."

Ephemeris of Asteroid (719) MT, Albert.—The little asteroid (719) Albert will be in opposition to the sun on January 28, 1917. As the planet is so small and as it will be at such a great distance from both the sun and earth, there will be no hope of its being photographed. I am sending ephemeris thinking that it might be of interest to astronomers to know where it will be during January, February and the first two weeks of March 1917. The ephemeris and constants are based upon the elements in the 1917 Berlin Jahrbuch.

1917 Greenwich Midnight	α h m s	δ ° ′ ″	log r	log Δ
Jan. 1	9 6 1	+3 56 14	0.53590	0.41655
9	8 59 35	+4 14 22	0.53932	0.41023
17	8 53 0	+4 40 40	0.54264	0.40685
25	8 45 39	+5 14 5	0.54584	0.40671
Feb. 2	8 38 14	+5 52 58	0.54892	0.41005
10	8 31 9	+6 35 19	0.55188	0.41678
18	8 24 15	+7 19 10	0.55476	0.42660
26	8 19 20	+8 2 38	0.55752	0.43910
Mar. 6	8 15 6	+8 43 57	0.56016	0.45369
14	8 12 9	+9 22 7	0.56272	0.46983

CONSTANTS.

$$x = r\,[9.99993]\ \sin\ (275\ 26\ 43.60 + u)$$
$$y = r\,[9.98928]\ \sin\ (185\ 12\ 42.00 + u)$$
$$z = r\,[9.34256]\ \sin\ (190\ 3\ 4^s.10 + u)$$

FRANK E. SEAGRAVE.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, October-November, 1916.

We welcome as new members of the Association this month, Messrs. Robert Barnes, "Bs," of Wheaton, Ill., and F. L. Ducharme, "D," of Arlington, Mass.

Mr. Richter's list of observations for last month was received too late for publication and is included in this month's report.

Thanks are due Mr. G. B. Lacchini for a number of blue prints for distribution and the Association is also indebted to Mr. C. B. Lindsley for plotting and publishing in POPULAR ASTRONOMY many interesting curves from the data contributed during the year.

VARIABLE STAR OBSERVATIONS October-November, 1916.

Oct. 0 = J. D. 2421137; Nov. 0 = 2421168; Dec. 0 = 2421198

001046
X Androm.

J.D. 242	Est.	Obs.
1139.6	13.6	B
42.6	<12.8	Bu
59.6	<11.4	V

001032
S Sculptoris

1160.6	10.2	Ba
62.8	10.0	Ho

001726
T Androm.

1138.6	11.2	Ba
39.6	11.7	Y
40.6	11.8	Ly
40.7	11.3 ±	V
42.6	12.0	M
42.6	12.2	Bu
54.5	12.2	Nt
59.6	<11.5	V
60.6	<10.7	S
60.7	10.6	R
64.6	<11.5	Pi

001755
T Cassiop.

1138.6	10.1	M
42.6	11.3	Bu
50.6	10.4	M
55.6	10.1	Nt
60.6	<10.1	S
63.5	11.0	Pi

001838
R Androm.

1138	8.7	ϒ
39.5	10.3	O
40.7	10.0	V
42.6	10.0	M
44.6	9.5	B
44.6	9.6	Bu
51.5	10.7	O
54.5	10.8	O
54.6	9.7	Hu
54.6	9.3	M
55.6	10.7	Nt
59.6	10.8	V
59.7	10.3	Mu
60.7	10.6	R
64.6	10.6	Pi

001909
S Ceti

1138.6	8.4	Ba
39.6	8.4	Y
42.6	8.3	Bu
51.7	8.1	M
54.5	8.2	Y
55.9	8.5	Ho
58.8	8.5	Pi

S Ceti

J.D. 242	Est.	Obs.
60.6	8.3	Ba
60.7	8.3	R
61.6	8.7	S
62.8	8.6	Ho
63.5	8.5	Hu

002614
T Piscium

1163.6	11.0	M

003179
Y Cephei

1138.6	11.7	Ba
42.6	<12.4	Bu
54.6	9.2	Hu

004047
U Cassiop.

1138.6	9.4	M
38.6	12.0	Ba
39.6	11.8	Y
42.6	11.4	Bu
51.5	12.1	Y
54.5	12.4	Nt
58.5	12.5	B
63.5	<12.5	Pi
65.5	12.6	Y

004132
RW Androm.

1139.5	8.6	O
41.6	8.3	M
42.5	8.7	O
42.6	8.5	Bu
51.5	9.2	O
54.6	9.3	M
55.6	9.7	Nt
64.6	9.2	Pi
70.5	9.9	O

004435
V Androm.

1138.6	10.2	Ba
39.5	10.4	O
42.6	11.1	M
42.6	10.6	Bu
45.6	10.7	Ly
51.5	11.0	O
54.6	11.3	Hu
55.6	11.0	Nt
64.6	12.2	Pi

004533
RR Androm.

1138.6	9.2	Ba
39.5	9.4	O
42.5	9.6	O
42.6	9.5	M
42.6	9.4	Bu
45.6	9.6	Ly

RR Androm.

J.D. 242	Est.	Obs.
51.5	9.6	O
54.6	8.8	Hu
55.6	10.0	Nt
70.5	10.6	O

004746
RV Cassiop.

1138.6	10.4	M
38.6	10.2	Ba
39.5	10.7	O
42.6	10.9	Bu
51.5	11.0	O
55.6	9.7	Nt

004958
W Cassiop.

1129.4	10.2	L
38.6	9.7	M
38.6	9.0	Ba
42.6	10.4	Bu
45.6	10.4	Ly
49.5	9.2	B
51.5	10.1	Y

010102
Z Ceti

1138.6	9.5	Ba
39.6	9.8	Y
54.5	10.0	Y
55.9	11.8	Ho
58.8	10.8	Pi
60.6	10.6	Ba

010940
U Androm.

1138.6	11.9	Ba
64.6	11.2	Pi

011208
S Piscium

1138.6	<13.6	Ba
59.6	<11.3	V
60.6	<13.6	Ba

011272
S Cassiop.

1138.6	9.6	M
39.5	9.5	O
42.6	9.2	Bu
44.5	9.0	B
44.6	9.1	Bu
54.5	9.0	O
60.7	9.2	R
63.5	8.8	Pi

012203
R Sculptoris

1162.8	5.7	Ho

012350
RZ Persei

J.D. 242	Est.	Obs.
1139.6	12.6	Y
42.6	<12.6	Bu
65.5	12.9	Y

012502
R Piscium

1138.6	8.0	Ba
39.6	8.6	Y
42.6	8.0	Bu
59.7	7.5	M
60.0	7.5	Ho
61.6	7.5	S
61.6	7.8	Pi
61.6	8.0	Wpi

013238
RU Androm.

1142.6	<12.1	Bu

013338
Y Androm.

1142.6	<12.4	Bu

014958
X Cassiop.

1138	<11.5	ϒ
38.6	11.5	M
42.6	<12.3	Bu
51.5	12.1	Y
54.6	12.2	Nt
58.6	11.1	B
63.5	11.3	Pi
65.5	12.2	Y

015354
U Persei

1138.6	7.9	Ba
39.6	8.0	Pi
39.6	7.7	Wpi
40.6	8.0	M
40.7	7.8 ±	V
42.6	8.0	Bu
59.6	8.1	V
59.7	8.0	Wh
59.7	7.9	Mu
63.6	8.0	Hu

015912
S Arietis

1142.6	<12.5	Bu

021024
R Arietis

1138.6	7.8	Ba
40.6	8.0	Pi
42.7	8.4	M
45.6	8.2	Bu
51.6	8.2	Pi
61.6	9.3	S
64.6	9.4	Pi
65	9.3	ϒ
70.5	9.6	O

021281
Z Cephei

J.D. 242	Est.	Obs.
1159.6	<11.5	V

021403
o Ceti

1133.4	6.7	L
38.6	6.3	Ba
39.7	6.2	Mu
42.6	6.0	L
42.6	6.3	Bu
45.6	6.2	Bu
52	5.7	G
53	5.5	G
53.6	5.8	Bu
54	5.4	G
54.7	4.7	E
55	5.2	G
55.9	4.0	Ho
56.7	4.6	Ba
58.8	4.5	Pi
59	5.0	G
59.6	4.3	Ba
59.7	4.4	M
59.7	4.7	Mu
61	4.7	G
61.6	4.1	Ba
61.8	4.1	Mu
62.8	4.0	Mu
62.8	4.3	E
63.5	4.2	Ph
63.6	4.0	Hu
63.6	3.8	Cr
64	4.5	G
65	4.3	G
65.7	4.2	Mu
66.7	4.0	Mu
67.6	4.7	Bu
67.7	4.2	Mu
68.7	4.0	Mu
69.7	3.8	O

021558
S Persei

1133.4	9.6	L
38.6	9.3	Ba
40.6	10.1	M
45.6	9.7	Bu
51.5	9.2	B
58.6	10.4	De
58.6	10.1	Pi
65.6	9.9	Bu

022101
R Ceti

1139.6	<12.0	Y
45.6	<12.0	Bu
60.0	10.5	Ho

022150
RR Persei

1139.6	8.6	Y

VARIABLE STAR OBSERVATIONS October-November, 1916—Continued.

023080
RR Cephei

J.D. 242	Est.	Obs
1159.6	<11.5	V

023133
R Triang.

1139	9.7	T
39.6	9.3	Y
42	9.4	T
44	9.5	T
44.6	8.9	B
44.6	9.0	Bu
51	9.0	T
54	9.0	T
54.7	8.5	M
58.6	8.5	B
63	8.4	T
63.6	8.0	Hu
64	8.1	T
64.6	8.6	Pi
65	7.9	T
65	9.4	G
65.7	9.1	Mu
66	7.6	T
70.5	8.3	O

024356
W Persei

1129.4	9.3	L
39.6	9.7	Pi
39.6	9.4	Wpi
40.6	10.5	M
40.6	9.6	Ly
42.6	9.1	Wh
54.5	10.0	O
59.6	9.2	Bu
59.6	9.5	Wh
59.7	9.3	Mu
63.6	9.2	Hu

030514
U Arietis

1141.6	<12.6	Y
41.6	13.0	B
41.7	<12.8	Ba

031401
X Ceti

1160.0	9.2	Ho

032043
Y Persei

1140.6	9.7	M
41.6	9.8	B
58.7	10.2	Pi
59.6	10.4	Bu
63.6	9.5	Hu

032335
R Persei

1141.6	12.2	Y
54.5	11.6	Y
58.7	10.9	Pi
65.5	11.1	Y

033362
U Camelop.

J.D. 242	Est.	Obs.
1139.6	8.3	Pi
39.6	8.5	Wpi
42.6	7.4	Wh
67.6	8.2	M

034625
U Eridani

1155.9	9.2	Ho

035124
T Eridani

1155.9	7.6	Ho

035915
V Eridani

1155.9	8.7	Ho

041619
T Tauri

1141.9	10.6	M

042215
W Tauri

1139.7	10.3	Ba
41.7	10.0	Ba
41.9	10.6	M
54.6	10.1	Ba
54.7	10.4	M
59.6	10.0	Ba
63.7	10.3	Sp

042209
R Tauri

1154.7	<13.0	Nt
59.7	<10.6	V
63.6	<12.5	Y
63.7	13.5	Sp

042309
S Tauri

1154.7	<13.0	Nt
59.7	<10.6	V
63.6	<12.5	Y
63.7	<13.5	Sp

043065
T Camelop.

1141.6	12.7	Y
65.5	12.9	Y
65.9	<10.0	M

043208
RX Tauri

1154.7	11.0	Nt
64.6	11.0	Y

043274
X Camelop.

1129.4	10.8	L
38.6	11.8	Cr
39.6	12.2	Pi
39.6	12.0	Wpi

X Camelop.

J.D. 242	Est.	Obs.
1139.7	12.0	Ba
41.6	12.1	Ba
41.6	12.0	Y
45.6	11.9	Bu
51	<11.1	T
54	<11.1	T
54.5	12.8	Y
54.7	13.0	Ba
59.7	<10.6	V
61.6	<12.3	Cr
63	<11.1	T
63.6	<12.3	Pi
63.7	13.2	Sp
64	<11.1	T
65	<11.1	T
65.5	12.9	Y
66	<11.1	T

044617
V Tauri

1154.7	10.9	M
59.7	10.7	V
63.7	10.6	Sp
64.6	10.0	Y

045514
R Leporis

1129.0	7.5	Ho
42.6	7.1	L
55.9	7.2	Ho
58.8	8.3	Pi
60.0	7.1	Ho
63.7	8.6	M

050003
V Orionis

1160.0	9.2	Ho
61.9	9.2	M

050022
T Leporis

1129.0	10.7	Ho
55.9	10.4	Ho
58.8	11.3	Pi
60.0	10.2	Ho
62.8	11.3	E

050953
R Aurigae

1159.7	9.5	M
63.7	9.3	Sp

052034
S Aurigae

1144.6	9.1	L
59.7	9.0	M
64.7	8.9	Pi

052036
W Aurigae

1139.7	<12.5	Ba
59.6	<12.5	Ba
64.7	<13.4	Sp

052405
S Orionis

J.D. 242	Est.	Obs.
1129.0	10.1	Ho
55.9	9.9	Ho
60.0	9.8	Ho
61.9	9.6	M

053005
T Orionis

1129.0	9.9	Ho
41.9	<9.7	M
42.6	10.1	L
55.8	9.8	Ho
58.8	10.0	Pi
60.0	10.1	Ho
64.7	10.7	Sp

053068
S Camelop.

1141.6	8.6	Y
64	8.2	T
65	8.2	T
65.9	9.2	M

053531
U Aurigae

1159.7	9.7	Ba

054319
SU Tauri

1139.7	9.8	Ba
41.7	9.8	Ba
44.7	9.5	Ba
59.6	9.5	Ba
60.6	9.6	Ba
61.6	9.5	Ba
62.8	9.4	E
64.9	9.5	E

054920
U Orionis

1144.6	9.3	L
58.8	10.2	Pi
59.7	9.6	M
62.8	9.9	E

054978
V Camelop.

1139.7	<12.8	Ba
41.6	<12.8	Y
41.6	<12.8	Ba
45.7	12.2	Bu
54.6	<12.8	Ba
59.6	<13.0	Ba
63.7	9.9	Sp
65.9	<10.0	M

053353
Z Aurigae

1151.7	9.7	M
64.7	9.7	Pi

060124
S Leporis

J.D. 242	Est.	Obs.
1129.0	6.2	Ho
55.9	6.5	Ho
60.0	6.5	Ho

060450
X Aurigae

1139.7	9.8	Ba
64.7	8.7	Pi

060547
SS Aurigae

1129.4	<11.6	L
30.4	<11.6	L
39.7	<13.0	Ba
41.6	<12.4	Y
42.6	<12.4	L
44.6	<12.4	L
54.7	<12.8	Ba
59.6	<13.0	Ba
60.6	<13.0	Ba
62.8	<12.4	E
63.7	<13.5	Sp
64.6	<12.4	Y
64.7	<12.0	Pi
64.9	<12.4	E
65.6	<13.5	B

061702
V Monoc.

1129.0	10.5	Ho
55.9	9.0	Ho
60.0	8.5	Ho

063159
U Lyncis

1159.6	11.6	Ba

063558
S Lyncis

1159.6	9.0	Ba
64.6	9.7	Y
64.7	9.2	Sp

064932
Nova Gemin.

1142.6	<12.0	L

065111
Y Monoc.

1162.8	12.0	E
65.9	11.6	M

065208
X Monoc.

1129.0	7.2	Ho
42.7	7.5	L
55.9	7.6	Ho
60.0	7.8	Ho
61.9	8.0	M

065355
R Lyncis

1164.6	<12.4	Y
64.7	12.4	Sp

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070122a
R Gemin.

J. D. 242	Est.	Obs.
1158.7	8.1	Pi
62.8	8.2	E
65.8	8.1	M

070122b
TW Gemin.

J. D. 242	Est.	Obs.
1158.7	8.4	Pi
62.8	8.4	E
65.8	8.3	M

070122c
Z Gemin.

J. D. 242	Est.	Obs.
1162.8	12.3	E
65.8	11.0	M

070312
R Can. Min.

J. D. 242	Est.	Obs.
1142.7	9.2	L
65.8	9.3	M

071713
V Gemin.

J. D. 242	Est.	Obs.
1169.9	9.5	M

072708
S Can. Min.

J. D. 242	Est.	Obs.
1140.6	8.5	Ly
41.9	8.6	M
58.8	8.3	Pi
61.9	8.4	M
62.8	8.6	E
65.8	8.3	M

072811
T Can. Min.

J. D. 242	Est.	Obs.
1161.9	9.6	M

073508
U Can. Min

J. D. 242	Est.	Obs.
1140.6<11.8		Ly
42.7	11.4	L
65.8	10.2	M

073723
S Gemin.

J. D. 242	Est.	Obs.
1158.8<12.4		Pi

074323
T Gemin.

J. D. 242	Est.	Obs.
1158.8	11.2	Pi
69.9	12.0	M

074922
U Gemin.

J. D. 242	Est.	Obs.
1142.6<11.7		L
44.7<12.3		L
58.8<12.3		Pi
62.8<12.4		E
64.9<12.4		E
65.8<10.9		M
69.9<11.7		M

075613
U Puppis

J. D. 242	Est.	Obs.
1129.0<12.2		Ho
55.9<12.0		Ho

081112
R Cancri

J. D. 242	Est.	Obs.
1144.7	10.8	L
69.9	11.3	M

081617
V Cancri

J. D. 242	Est.	Obs.
1164.9	8.1	E
69.9	7.8	M

082405
RT Hydrae

J. D. 242	Est.	Obs.
1129.0	8.1	Ho
44.6	7.9	L
55.9	7.9	Ho

083019
U Cancri

J. D. 242	Est.	Obs.
1164.9<11.9		E

084803
S Hydrae

J. D. 242	Est.	Obs.
1164.9	10.0	E
69.9	10.4	M

085008
T Hydrae

J. D. 242	Est.	Obs.
1164.9	8.8	E
69.9	9.0	M

085120
T Cancri

J. D. 242	Est.	Obs.
1144.7	9.5	L

090151
V Urs. Maj.

J. D. 242	Est.	Obs.
1142.6	10.3	L
55.0	9.1	Ho
65.9	10.6	M

090425
W Cancri

J. D. 242	Est.	Obs.
1169.9	11.6	M

093178
Y Draconis

J. D. 242	Est.	Obs.
1151.6	13.9?	Y

093934
R Leo. Min.

J. D. 242	Est.	Obs.
1165.0	<9.4	E
69.9	10.7	M

094211
R Leonis

J. D. 242	Est.	Obs.
1144.7	6.0	L
61.9	6.9	M
65.0	6.9	E
65.9	7.0	M
69.9	7.4	M

094622
Y Hydrae

J. D. 242	Est.	Obs.
1160.0	6.4	Ho

095421
V Leonis

J. D. 242	Est.	Obs.
1169.9	12.2	M

103769
R Urs. Maj.

J. D. 242	Est.	Obs.
1138.5	7.7	Ba
40.6	7.6	Ly
41.6	7.2	M
41.7	7.6	Ba
45.7	7.4	Bu
49.6	7.4	Ly
50.6	7.5	Ba
51.5	7.8	Cr
54.6	7.6	M
54.6	7.9	Cr
55.6	7.4	Ly
59.6	7.5	Ba
63.5	7.3	Cr
64.6	7.7	M
64.6	7.3	Cr
64.6	7.5	Ly

104620
V Hydrae

J. D. 242	Est.	Obs.
1160.0	7.5	Ho

123160
T Urs. Maj.

J. D. 242	Est.	Obs.
1138.5	12.4	Ba
45.6	12.3	Ly
47.7<11.4		Ba
55.6	12.4	Ly
59.5<12.0		Ba

123459
RS Urs. Maj.

J. D. 242	Est.	Obs.
1137.6	10.1	Bu
38.5	9.5	Ba
41.6	10.3	M
43.5	9.8	Ba
45.7	10.4	Bu
59.5	10.9	Ba
59.5	10.0	Wh

123961
S Urs. Maj.

J. D. 242	Est.	Obs.
1137.6	8.2	Bu
38.3	8.2	L
38.5	8.2	Ba
40.6	8.3	Ly
43.5	8.2	Ba
45.7	8.2	Bu
49.5	8.3	B
49.6	8.5	Ly
54.6	8.4	M
55.6	8.7	Ly
58.5	8.9	Wh
59.5	8.6	Ba
64.6	9.0	Ly

133273
T Urs. Min.

J. D. 242	Est.	Obs.
1139.6<11.4		Pi
41.6	12.1	Ba
45.7	12.2	Bu
59.5	12.2	Ba

134440
R Can. Ven.

J. D. 242	Est.	Obs.
1138.3	8.9	L
38.5	8.9	Ba
40.6	8.6	M
59.5	8.4	Ba
64.6	8.2	M

141567
U Urs. Min.

J. D. 242	Est.	Obs.
1139.5	9.0	Pi
39.5	8.8	Wpi
41	8.7	S
41.6	8.5	Ba
45.7	8.4	Bu
49.5	8.4	B
57.5	9.0	Wh
57.6	7.8	M
59.5	8.3	Ba
64.6	8.3	M

141954
S Bootis

J. D. 242	Est.	Obs.
1138.5	12.0	Ba
42.6<10.6		M
54.5<12.0		Pi
60.5<12.3		Ba

142539
V Bootis

J. D. 242	Est.	Obs.
1138.3	8.9	L
41.6	9.5	R
42.5	8.8	Ba
42.6	8.6	M
48.3	9.4	L
54.5	9.1	Pi
58.5	9.4	Wh
59.5	9.2	Ba

142584
R Camelop.

J. D. 242	Est.	Obs.
1138.5<12.7		Ba
41.6<12.7		Y
45.6<12.0		Ly
54.6<11.2		Wh
54.6	12.7	Y

143227
R Bootis

J. D. 242	Est.	Obs.
1138.3	11.7	L
38.5	11.3	Ba

144918
U Bootis

J. D. 242	Est.	Obs.
1138.5	10.3	Ba

151714
S Serpentis

J. D. 242	Est.	Obs.
1138.5	9.2	V
42.5	9.5	Ba
57.6	9.8	M
60.5	10.1	Ba

151731
S Cor. Bor.

J. D. 242	Est.	Obs.
1138.5	12.9	Ba
41.6<12.8		Ba

153378
S Urs. Min.

J. D. 242	Est.	Obs.
1129.4	11.0	L
39.5	10.8	Pi
39.5	11.0	Wpi
39.7	10.1	R
39.7	10.7	Mu
40.6	10.7	Ly
41.6	10.4	Ba
45.7	11.2	Bu
49.5	10.3	B
49.6	11.0	Ly
55.6	11.1	Ly
57.6	11.0	M
58.5	10.6	Wh
59.5	10.6	Ba

154428
R Cor. Bor.

J. D. 242	Est.	Obs.
1102.7	5.6	R
03.7	5.6	R
04.7	5.6	R
05.7	5.7	R
28	6.0	G
29.3	6.0	L
30	6.0	G
30.3	6.0	L
38.3	6.0	L
38.5	6.0	Ba
39.5	6.0	O
39.6	5.7	R
39.7	6.1	Mu
40.5	6.4	V
40.5	6.0	Cr
40.6	6.0	M
41.6	6.1	Ba
42.5	6.0	O
42.5	6.1	Ba
43.5	6.1	Ba
43.6	6.3	Gr
44.3	6.0	L
44.5	6.0	Ba
45.3	6.0	L
48.3	6.0	L
48.6	6.0	Ba
50	6.0	G

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R Cor. Bor.

J.D. 242	Est.	Obs.
51.5	6.0	O
51.5	6.0	Cr
52	5.9	G
54.5	6.0	O
54.5	6.0	Pi
55	6.0	G
57.5	6.1	Wh
59	6.0	G
59.5	6.0	Ba
59.6	6.3	Mu
60.5	6.0	Ba
60.6	6.3	Mu
61	6.0	G
61.5	6.0	Ba
61.6	6.3	Mu
62.6	6.1	Mu
63.5	6.6	Ph
63.6	6.0	Cr

154536
X Cor. Bor.

1138.5	13.5	Ba

154539
V Cor. Bor.

1140.6	9.4	M
42.5	8.1	Ba
54.5	8.5	Pi
59.5	7.2	Ba

154615
R Serpentis

1138.5	12.7	Ba
45.6	<12.0	Ly

155229
Z Cor. Bor

1142.5	<13.0	Ba

155847
X Herculis

1129.4	6.2	L
30.3	6.6	L
38.3	6.3	L
39.5	6.6	O
39.7	6.5	Mu
42.5	6.5	O
46.3	6.4	L
51.5	6.4	O
54.5	6.3	O
59.5	6.4	Ba
59.6	6.5	Mu
60.6	6.4	Mu
61.6	6.4	Mu
65.6	6.4	Mu
66.6	6.2	Mu

160118
R Herculis

1142.5	<13.0	Ba
54.5	<11.4	V
59.5	<12.9	Ba

160210
U Serpentis

J.D. 242	Est.	Obs.
1138.5	8.6	Ba
57.6	8.5	M
59.5	8.1	Ba

160625
RU Herculis

1138.5	9.5	V
39.6	9.6	M
41.6	9.2	B
42.5	9.2	Ba
54.5	10.5	O
54.5	10.5	Pi
54.5	10.7	Wpi
59.5	9.9	V
59.5	10.4	Ba
63.5	10.7	Nt

161138
W Cor. Bor.

1138.5	11.3	Ba
40.6	11.2	Ly
45.6	11.4	Ly
54.5	<11.5	Pi
59.5	11.9	Ba
65.5	12.1	B

162112
V Ophiuchi

1130.3	9.7	L

162119
U Herculis

1139.7	9.3	Mu
39.7	9.6	R
40.6	9.6	Ly
41.6	9.1	B
42.5	9.6	O
42.5	9.4	Ba
49.6	9.8	Ly
51.5	10.1	O
51.5	9.4	Y
51.6	9.7	Pi
55.6	10.1	Ly
59.5	10.0	Ba
59.6	9.3	Mu
63.5	9.4	Nt

162807
SS Herculis

1130.3	<11.8	L
38.3	11.3	L
38.5	<11.4	V
38.5	11.2	Ba
42.5	10.7	Ba
54.5	10.2	V
54.5	10.2	Pi
54.5	10.3	Wpi
59.5	10.0	Ba

163137
W Herculis

J.D. 242	Est.	Obs.
1138.5	13.1	Ba
39.5	13.0	Y
51.6	12.8	M
59.5	11.6	Ba

163172
R Urs. Min.

1139.6	10.1	Wpi
39.6	10.0	Pi
39.7	9.4	R
41.6	9.5	B
41.6	10.2	M
41.6	9.5	Ba
45.7	9.8	Bu
48.6	9.5	Ba
57.5	9.7	Wh
69.5	10.1	Ba
64.6	10.3	M

163266
R Draconis

1138.5	11.4	Cr
40.6	11.4	Ly
41.6	11.6	M
41.6	11.3	Cr
41.6	11.4	Ba
44.6	12.8	Ba
45.6	11.2	Ly
45.7	11.5	Bu
48.6	10.9	Ba
49.6	11.2	M
51.6	10.8	Cr
54.5	10.6	O
54.6	10.5	Cr
54.6	10.5	Pi
54.6	11.2	Wpi
55.6	11.0	Ly
57.7	10.7	Wh
58.6	10.5	Cr
59.5	10.3	Ba
61.6	10.4	Cr
63.5	10.3	Cr
65.6	9.8	B
70.5	9.3	O

164055
S Draconis

1139.7	8.8	R
41.6	9.0	M
41.6	8.7	Ba
45.7	9.2	Bu
50.6	8.8	M
54.6	9.2	Pi
54.6	9.1	Wpi
59.5	8.8	Ba

164715
S Herculis

1139.6	11.1	Y
39.6	10.7	M

S Herculis

J.D. 242	Est.	Obs.
1142.5	10.9	Ba
51.5	10.6	B
54.6	10.7	Pi
54.6	10.7	Wpi
59.5	10.2	Ba

165631
RV Herculis

1139.5	10.9	O
39.6	11.4	B
39.6	11.0	M
39.7	10.7	R
41.6	10.8	Ba
45.7	11.0	Bu
54.5	10.9	O
54.5	11.6	WPi
54.5	12.0	Pi
59.5	11.6	Ba
63.5	12.1	Nt

170627
RT Herculis

1139.6	<12.6	Y
39.6	<13.2	B
60.5	<12.8	Ba

171401
Z Ophiuchi

1142.5	11.8	Ba
59.5	12.0	Ba

171723
RS Herculis

1138.6	12.2	Hu
39.6	11.6	Y
42.5	12.1	Ba
54.6	10.5	Nt
54.6	10.5	Pi
54.6	10.5	Wpi
59.5	10.1	Ba
65.5	9.5	B

172809
RU Ophiuchi

1142.5	<12.6	Ba
51.6	12.2	M
53.6	12.1	Bu
54.6	<11.6	V
59.5	12.0	Ba
68.5	<12.2	V

175111
RT Ophiuchi

1142.5	<12.5	Ba
64.6	<11.0	V
68.5	<11.0	V

175458
T Draconis

1138.6	9.2	Hu
38.6	10.6	V
41.6	9.0	B

T Draconis

J.D. 242	Est.	Obs.
41.6	9.7	M
42.6	9.7	Ba
51.6	9.0	B
54.6	10.0	V
54.6	10.1	Pi
54.6	9.8	Wpi
59.5	9.4	Ba
68.6	10.2	V

175519
RY Herculis

1139.5	10.8	O
39.6	11.0	Y
42.6	10.9	Ba
51.5	11.3	O
51.5	11.9	B
54.5	12.1	Pi
54.5	11.9	Wpi
59.5	12.2	Ba
63.5	13.1	Nt

180531
T Herculis

1139.6	13.0	Ba
39.6	9.7	M
42.6	12.7	Ba
49.6	<11.0	Bu
51.6	11.0	Pi
59.6	12.7	Ba

180565
W Draconis

1141.6	9.0	B
41.6	9.0	M
41.6	9.0	Ba
51.6	9.2	B
54.6	9.7	Pi
54.6	9.5	Wpi
59.6	9.3	Ba
64.6	9.9	Y

180666
X Draconis

1141.6	<11.5	M

180931
TV Herculis

1130.3	<11.7	L
38.3	<11.5	L

181103
RY Ophiuchi

1138.6	8.0	V
42.6	8.4	Ba
45.7	9.5	Bu
57.6	9.6	M
59.5	10.2	Ba
59.6	9.2	V
64.5	10.9	Pi
68.5	11.0	V

VARIABLE STAR OBSERVATIONS October-November, 1916—Continued

181136
W Lyrae

J.D. 242	Est.	Obs.
1137.6	9.2	Bu
38.6	9.0	Gr
39.5	8.9	O
39.6	9.1	M
39.7	8.9	R
39.7	8.9	Mu
41.6	8.9	Ba
42.6	9.2	O
42.6	9.0	B
42.6	9.3	Gr
45.7	9.2	Bu
51.5	9.4	O
51.6	9.5	B
53.5	9.5	O
54.6	10.0	Wh
54.6	9.4	M
54.6	10.0	Gr
59.6	10.0	Mu
59.6	10.3	Ba
60.6	10.0	Gr
61.5	10.4	Pi
61.5	10.3	Wpi
64.5	10.0	O
65.7	10.2	Mu
67.6	<10.1	Gr

181518
Y Sagittarii

1155	5.9	G
56	5.9	G

182224
SV Herculis

1159.6	<12.7	Ba
65.6	<13.7	B

182306
T Serpentis

1038	11.6	T
39	11.6	T
42	11.3	T
44	11.5	T
45.7	<10.8	Bu
51	11.5	T
54.6	<11.5	V
59.6	<12.3	Ba
63	11.6	T
65	<11.6	T
68.5	<11.0	V

182619
U Sagittarii

1155	7.0	G
56	7.1	G

183225
RZ Herculis

1139.5	10.3	O
42.6	9.9	Ba
54.6	11.0	Pi
54.6	11.3	Wpi
59.6	11.5	Ba

183308
X Ophiuchi

J.D. 242	Est.	Obs.
1130.3	6.5	L
38.6	6.2	V
39.7	7.4	R
41.6	6.7	Ba
42.6	7.0	M
45.6	6.6	Ly
45.7	7.4	Bu
48.6	6.8	Ba
49.6	6.7	Ly
54.6	7.2	V
55	7.5	G
59.6	7.0	Ba
64.6	7.7	Pi
68.6	6.9	V

184132
RY Lyrae

1159.6	13.5	Ba

184205
R Scuti

1102.7	5.3	R
03.7	5.0	R
04.7	4.8	R
05.7	5.9	R
08	5.9	G
28	5.8	G
29.3	5.4	L
30.3	5.3	L
33.4	5.3	L
37.6	5.2	Bu
38.4	5.3	L
38.5	5.9	Ba
38.6	5.8	Pi
38.6	5.0	M
38.6	6.0	Hu
39.5	5.9	O
39.6	6.1	R
39.7	5.6	Mu
40.6	5.3	Cr
41.6	5.9	Ba
41.6	6.5	R
42.5	5.9	Ba
42.5	5.8	O
42.5	5.4	Bu
42.6	5.6	Cr
43.5	5.9	Ba
44.5	5.8	Ba
44.6	5.9	R
45.3	5.3	L
45.5	5.9	Bu
46.3	5.4	L
47.5	6.0	Bu
47.6	5.5	M
48.3	5.3	L
48.5	6.0	Bu
48.6	5.6	Ba
49.5	6.0	Bu
50	5.8	G

R Scuti

J.D. 242	Est.	Obs.
1150.6	5.8	Ba
51.5	5.5	Pi
51.5	5.8	O
51.5	5.7	Bu
51.6	5.8	Cr
52	5.8	G
52.5	5.7	Bu
53	5.6	G
53.5	5.8	O
54	5.6	G
54.5	5.8	O
54.6	5.7	Cr
55	5.2	G
56	5.3	G
56.6	5.7	R
57.6	5.4	Wh
59	5.2	G
59.5	5.5	Ba
59.6	5.3	Mu
60.5	5.4	Ba
60.6	5.0	R
60.6	5.0	Mu
61.5	5.5	Ba
61.6	5.5	Cr
61.6	5.1	Mu
62.6	5.2	Mu
63.5	5.2	Ph
63.6	5.2	Cr
63.6	5.1	Mu
64.5	5.6	O
65	5.0	G
65.6	5.1	Mu
66.6	5.3	Cr
66.6	5.2	Mu
70.5	5.3	O

184243
RW Lyrae

1159.6	<13.5	Ba
65.5	<13.7	B

185032
RX Lyrae

1151.6	<13.0	M
53.6	<11.9	Bu
59.6	<13.1	Ba

185634
Z Lyrae

1141.6	<13.3	Ba
59.6	<13.3	Ba

190108
R Aquilae

1130.3	7.6	L
33.4	7.9	L
38.6	8.1	M
38.6	7.4	V
41.6	7.5	Ba
42.6	7.5	B

R Aquilae

J.D. 242	Est.	Obs.
45.7	7.8	Bu
54.6	8.1	V
58.6	8.4	Pi
59.5	7.8	Ba
68.6	8.4	V

190529
V Lyrae

1139.6	<11.4	M
59.6	<13.0	Ba

190926
X Lyrae

1139.6	9.0	M
39.7	8.8	R
41.6	8.7	Ba
59.5	9.0	Ba

190967
U Draconis

1141.6	10.5	M
49.6	11.2	M
54.6	12.1	Hu
63.6	12.1	Hu

191033
RY Sagittarii

1102.7	<10.0	R
03.7	10.4	R
04.7	<10.3	R
05.7	<10.3	R
29.3	<10.5	L
30.3	<10.5	L
31.4	<10.0	L
38.3	<10.5	L

191350
TZ Cygni

1141.6	10.2	Ba
51.6	10.6	Bu
54.6	10.9	Pi
59.6	10.7	Ba

191637
U Lyrae

1139.6	10.5	M
41.6	9.2	Ba
51.6	10.6	Bu
59.6	9.5	Ba
61.6	10.6	Pi
63.6	11.1	Nt

192508
U Aquilae

1152	6.3	G
54	6.3	G
55	6.3	G

192928
TY Cygni

1154.6	<11.2	V
60.5	<13.0	B
68.6	<11.2	V

193311
RT Aquilae

J.D. 242	Est.	Obs.
1160.5	<13.4	Ba

193449
R Cygni

1131.6	8.6	Ba
41.6	8.6	R
42	9.2	T
42.7	9.0	M
47.7	9.2	Wh
51.5	9.5	O
51.6	10.3	Bu
51.6	9.6	M
54	9.5	T
54.6	9.6	Pi
59.6	9.0	Ba
60.6	10.0	S
63	9.9	T
66	9.8	N
70.5	10.3	O

193509
RV Aquilae

1147.6	<11.2	M
51.6	12.3	Bu
60.5	11.1	Ba

193732
TT Cygni

1141.6	7.2	Ba
41.7	8.4	R
48.6	8.1	M
51.6	7.7	B
51.6	8.0	Bu
54.6	8.1	Hu
54.6	8.2	Pi
60.5	7.5	Ba

194048
RT Cygni

1141.6	8.1	Ba
41.7	8.5	R
42	8.0	T
42.7	8.5	M
47.7	7.8	Wh
51.5	7.5	O
51.6	8.0	Bu
54	7.9	T
54.6	7.0	Hu
54.6	7.8	Pi
59.6	7.4	Ba
60.6	7.7	S
63	7.9	T
70.5	7.2	O

194029
SU Cygni

1152	6.5	G
53	6.6	G
55	6.3	G
59	6.3	G
65	6.5	G

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194348
TU Cygni

J.D. 242	Est.	Obs.
1151.6	13.4	M
51.6	<11.7	Bu
54.6	<12.1	Pi

194604
X Aquilae

J.D. 242	Est.	Obs.
1154.6	<11.3	V
55.6	13.0	B
60.5	<12.9	Ba
68.6	<11.3	V

194632
χ Cygni

J.D. 242	Est.	Obs.
1151.6	13.2	M
51.6	<12.0	Bu
65.5	12.0	B

195116
S Sagittae

J.D. 242	Est.	Obs.
1102.7	5.7	R
03.7	5.5	R
04.7	6.0	R
05.7	6.3	R
39.5	5.4	O
39.6	5.6	R
39.7	5.7	Mu
41.6	5.8	R
42.5	6.0	O
51.5	5.8	O
52	5.5	G
53	5.6	G
53.5	5.2	O
54	5.8	G
54.5	5.4	O
55	5.8	G
55.5	5.4	O
56.6	5.5	R
59	6.1	G
59.6	5.7	Mu
60.7	5.7	R
60.6	5.6	Mu
61.6	5.4	Mu
63.6	5.4	Mu
64.5	5.4	O
65	5.6	G
65.6	5.8	Mu
66.6	5.9	Mu
67.6	6.0	Mu
70.5	5.2	O

195849
Z Cygni

J.D. 242	Est.	Obs.
1138.6	8.2	V
40.7	9.2	Ly
41.6	8.0	Ba
42	9.0	T
42.7	8.9	M
51.6	8.7	B
51.6	9.5	Bu
54	8.8	T

Z Cygni

J.D. 242	Obs.	Est.
1154.6	9.2	V
54.6	9.2	Pi
59.7	9.5	Wh
60.5	9.4	Ba
60.7	10.5	Wpi
63.6	9.6	Nt
68.6	9.9	V

200212
SY Aquilae

J.D. 242	Est.	Obs.
1155.6	<12.2	B
60.5	<12.2	Ba

200357
S Cygni

J.D. 242	Est.	Obs.
1151.6	12.0	M
54.6	11.2	Pi
60.5	10.6	Ba
63.6	11.5	Nt
65.6	10.5	B

200647
SV Cygni

J.D. 242	Est.	Obs.
1141.7	9.0	R
48.6	8.0	Ba
51.6	8.3	Bu
53.7	9.0	M
54.6	9.0	Pi
59.7	9.2	Mu
60.5	8.1	Ba
60.7	9.4	Wpi
65.7	9.2	Mu

200747
RX Cygni

J.D. 242	Est.	Obs.
1159.7	7.8	Mu
65.7	7.9	Mu

200715a
S Aquilae

J.D. 242	Est.	Obs.
1138.6	9.0	M
41.7	9.4	R
42.6	9.3	B
44	9.6	T
48.6	9.4	Ba
51	9.4	T
51.6	9.6	B
51.6	8.6	Bu
54	9.6	T
58.6	9.8	Pi
58.6	9.6	De
60.5	9.5	Ba
63	9.9	T
66	9.9	T

200715b
RW Aquilae

J.D. 242	Est.	Obs.
1102.7	8.8	R
03.7	8.9	R
04.7	9.0	R

RW Aquilae

J.D. 242	Est.	Obs.
1105.7	8.9	R
38.6	8.0	M
39.6	8.9	R
41.6	8.8	R
42.6	9.3	B
44.6	9.0	R
48.6	9.4	Ba
51.6	9.3	B
51.6	8.8	Bu
56.6	9.2	R
58.6	9.2	Pi
58.6	9.1	De
60.5	9.1	Ba
60.6	9.1	R

200812
RU Aquilae

J.D. 242	Est.	Obs.
1142.6	12.6	B
51.6	13.1	B
60.5	13.1	Ba

200906
Z Aquilae

J.D. 242	Est.	Obs.
1147.6	11.2	M
51.7	12.4	Bu
60.5	12.8	Ba
62.7	<12.0	Ho
63.6	<12.0	Nt
65.6	12.0	B

200916
R Sagittae

J.D. 242	Est.	Obs.
1138.3	9.4	T
38.6	10.1	M
39.3	9.4	T
41.7	10.1	R
42.3	9.4	T
42.6	9.7	B
44.3	9.3	T
48.6	8.8	Ba
51.3	9.2	T
51.6	8.9	B
54.4	9.1	T
60.5	8.8	Ba
63.3	8.8	T
66.4	8.9	T

200938
RS Cygni

J.D. 242	Est.	Obs.
1140.7	8.6	Ly
41.7	8.7	R
45.7	8.7	Ly
48.6	8.8	M
48.6	8.2	Ba
51.7	8.5	Bu
54.6	8.8	Pi
54.6	8.0	Ba
64.7	8.9	Ly

201008
R Delphini

J.D. 242	Est.	Obs.
1155.5	12.0	B
60.6	12.2	Ba
63.6	12.4	M

201130
SX Cygni

J.D. 242	Est.	Obs.
1141.6	12.8	Y
51.6	12.9	M
54.6	<12.9	Y
60.6	13.1	Ba
63.6	13.0	Nt

201121
RT Capricorni

J.D. 242	Est.	Obs.
1130.4	6.3	L
38.3	6.9	L
61.5	6.9	Ba
62.8	7.4	Ho

201647
U Cygni

J.D. 242	Est.	Obs.
1148.6	8.2	Ba
51.6	10.0	M
51.7	9.9	Bu
54	<11.0	T
54.6	9.6	Pi
54.7	9.7	Wh
59.7	9.7	Mu
60.6	8.0	Ba
60.7	9.7	Wpi
61.6	<9.2	S
65	9.9	G
65.7	9.3	Mu

202539
RW Cygni

J.D. 242	Est.	Obs.
1142.7	9.0	M
44.7	8.9	R
48.6	7.8	Ba
51.7	8.0	Bu
54.6	8.8	Pi
60.6	7.9	Ba

202817
Z Delphini

J.D. 242	Est.	Obs.
1138.5	13.5	Ba
38.6	<11.2	V
54.6	<11.2	V
60.6	<12.9	Ba
68.6	<11.5	V

202946
SZ Cygni

J.D. 242	Est.	Obs.
1102.7	10.0	R
03.7	9.9	R
04.7	10.3	R
05.7	9.8	R
38.5	9.1	Ba
39.6	9.8	R
39.7	9.0	Ba

SZ Cygni

J.D. 242	Est.	Obs.
1141.6	9.3	R
41.6	8.7	Ba
42.6	9.0	Hu
44.4	10.0	R
44.5	8.8	Ba
44.6	9.1	Le
44.6	9.3	L
46.7	9.4	Le
47.7	9.5	Le
48.6	9.9	Ba
48.6	9.0	M
50.6	9.7	Ba
50.7	9.8	Le
51.6	9.4	B
51.7	9.7	Le
52.6	9.7	Le
54.6	9.0	Hu
54.6	9.4	Pi
54.7	9.0	Ba
54.8	8.9	Le
56.6	9.1	R
59.6	9.0	Le
59.6	9.2	Ba
60.6	9.3	Ba
60.6	10.0	R
60.7	9.6	Wh
61.5	9.3	Ba
62.7	9.5	Le
64.6	9.8	Le
65.7	9.8	Le

202954
ST Cygni

J.D. 242	Est.	Obs.
1138.6	9.4	Ba
51.7	9.8	Bu
54.6	10.3	Hu
54.6	10.4	Pi
60.6	10.3	Ba
63.6	10.9	Nt

203226
V Vulpeculae

J.D. 242	Est.	Obs.
1138.6	9.0	Ba
39.5	8.8	O
48.6	8.5	Ba
60.6	8.9	Ba
63.6	8.7	M

203611
Y Delphini

J.D. 242	Est.	Obs.
1155.5	11.5	B
60.6	11.1	Ba

203847
V Cygni

J.D. 242	Est.	Obs.
1142.7	10.9	M
51.6	9.3	B
60.6	9.2	Ba
63.6	9.9	Nt
67.6	10.2	M

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203816
S Delphini

J.D. 242	Obs.	Est.
1139.6	10.1	Y
54.6	9.4	Y
63.6	9.6	M
63.6	9.0	Nt

204016
T Delphini

J.D. 242	Obs.	Est.
1139.6	12.6	Y
54.6	12.9	Y
54.6	10.6	Pi
60.6	<13.0	Ba
63.6	<13.0	Nt
65.6	13.9	B

204318
V Delphini

J.D. 242	Obs.	Est.
1155.5	<12.8	B
60.6	<12.8	Ba

204405
T Aquarii

J.D. 242	Obs.	Est.
1154.6	7.5	Hu
61.5	7.5	Pi
61.5	7.8	Wpi
61.5	7.3	Ba
62.8	7.6	Ho
67.6	8.0	M

204846
RZ Cygni

J.D. 242	Obs.	Est.
1151.6	13.0	M
54.6	11.1	V
60.6	<13.1	Ba
68.6	<11.5	V

205017
X Delphini

J.D. 242	Obs.	Est.
1160.6	<13.0	Ba

205923
R Vulpeculae

J.D. 242	Obs.	Est.
1103.7	9.0	R
38.6	6.9	Ba
38.6	8.5	Hu
39.5	9.1	O
48.6	9.6	Ba
60.6	11.2	Ba
61.7	11.1	Pi
63.6	11.3	M

210116
RS Capricorni

J.D. 242	Obs.	Est.
1103.7	8.7	R
30.4	8.3	L
38.3	8.3	L
39.7	8.2	Mu
59.6	8.0	Mu
61.5	7.7	Ba
62.8	8.0	Ho
63.6	7.9	M
63.6	8.1	Pi

210129
TW Cygni

J.D. 242	Est.	Obs.
1161.5	<13.0	Ba
65.6	12.9	B

210382
X Cephei

J.D. 242	Est.	Obs.
1141.6	<13.2	Y

210868
T Cephei

J.D. 242	Est.	Obs.
1104.7	8.4	R
29 4	7.9	L
37.6	8.0	Bu
38.6	7.0	Ba
39.5	8.0	O
41.5	7.9	S
44.7	8.3	R
44.7	6.8	L
51.5	8.0	O
59.7	7.8	M
61.6	6.9	Ba
61.7	7.9	S

210903
RR Aquarii

J.D. 242	Est.	Obs.
1162.8	11.5	Ho

211614
X Pegasi

J.D. 242	Est.	Obs.
1138.6	9.6	Ba
51.7	9.0	Bu
58.7	9,9	Pi
59.6	10.0	Ba

211615
T Capricorni

J.D. 242	Est.	Obs.
1161.5	11.6	Ba
63.6	11.4	Pi

213244
W Cygni

J.D. 242	Est.	Obs.
1103.7	6.7	R
30.3	6.1	L
44.6	5.7	L
44.7	6.8	R
52	6.1	G
54	6.0	G
55	5.7	G

213678
S Cephei

J.D. 242	Est.	Obs.
1161.5	12.0	Ba

213753
RU Cygni

J.D. 242	Est.	Obs.
1148.6	8.6	M
58.6	8,9	Pi
58.6	8.6	De
61.6	8.5	Ba

213843
SS Cygni

J.D. 242	Est.	Obs.
1102.7	8.6	R
03,7	8.3	R
04.7	8 8	R
05.7	8.5	R
30.3	11.4	L
38.3	10.3	T
38.5	9.9	Cr
38.5	10.2	Ba
38.6	9.9	M
38.6	9.8	V
38.6	10.6	Hu
38.6	9.8	Pi
39.3	11.3	T
39.5	10.4	O
39.6	10.4	R
39.6	10.4	M
39.6	10.5	B
39.6	11.0	Mu
39.7	10.6	Ba
40.5	10.9	Cr
40.6	10.7	M
40.6	10.6	V
40.6	10.6	Pi
40.7	10.5	Ly
41.5	<9.6	S
41.6	10.8	Ba
41.6	10.3	Cr
41.6	10.5	R
42.3	11.3	T
42.5	11.0	Ba
42.5	10.9	Cr
42.5	11.4	Bu
42.6	11.3	M
42.6	10.8	B
42.7	10.9	Wh
43.5	11.3	Ba
44.3	11.3	T
44.5	11.4	Ba
44.5	11.3	B
44.6	11.3	Le
44.6	11.2	L
44.6	11.3	Bu
45.6	11.3	Bu
45.7	11.5	Ly
47.6	11.4	Bu
48.5	11.2	B
48.6	11.2	Bu
48.6	11.1	Ba
49.5	11.3	B
49.6	11.2	Bu
50.3	11.3	T
50.6	10.9	Ba
51.3	11.5	T
51.5	10.7	O
51.5	10.7	Pi
51.5	11.3	B
51.6	11.0	M
51.6	11.0	Bu
51.6	10.8	Cr

SS Cygni

J.D. 242	Est.	Obs.
1152.6	10.8	Bu
53.6	10.6	Bu
53.6	10.6	M
53.7	10.6	M
54.4	11.6	T
54.5	10.6	O
54.5	11.2	Nt
54.5	11.6	Cr
54.6	11.0	Ba
54.6	11.2	Hu
54.6	10.0	Bu
54.6	11.4	Pi
54.6	11.3	WPi
54,8	11.3	Le
55.5	11.1	Cr
55.5	11,2	B
55.5	11.2	Nt
56.6	<10.9	R
57.6	10.4	M
57.7	10.9	Wh
58.6	10.7	Cr
58.6	10.6	B
58.6	10.5	Pi
59.5	8.8	Ba
59.5	8.7	V
59.6	8.7	V
59.7	8.7	M
59.7	9.0	Le
59.8	9.5	Mu
60.5	8.7	Ba
60.5	8.2	Nt
60.6	8.1	R
60.6	8.4	S
60.7	8.6	Wh
60.7	9.5	WPi
61.5	8.8	Ba
61.6	9.2	WPi
61,6	8.6	S
61.6	8,9	Cr
62,5	8.5	Nt
62.5	8.5	Cr
62.7	9.1	Le
62.8	9.2	±E
63.3	9.3	T
63.5	9.4	V
63.5	8.9	Nt
63.5	9.0	Cr
63.5	9.2	Pi
63.6	9.1	M
63.6	9.2	Hu
63.7	9.4	Sp
64.3	9.5	T
64.4	9.4	T
64.5	9.5	O
64.6	9.4	Le
64.7	9.6	Sp
65	9.5	G
65.4	9.8	T
65.5	10.1	V
65.6	9.6	Hu

SS Cygni

J.D. 242	Est.	Obs.
1165.6	10.0	B
65.8	10.0	Le
66.3	10.2	T
66.4	10.2	T
67.6	10.7	M
68.6	10.6	V
70.5	<10.0	O

213937
RV Cygni

J.D. 242	Est.	Obs.
1104.7	8.0	R
38.6	6.8	Ba
44.6	7.7	L
48.6	8.1	M
51.6	8.2	Bu
54.6	7.0	Hu
55	7.2	G
58.6	8.5	Pi
61.6	6.9	Ba
65	8.8	T
65.6	7.1	Hu

214024
RR Pegasi

J.D. 242	Est.	Obs.
1161.5	<13.0	Ba

214058
Mu Cephei

J.D. 242	Est.	Obs.
1154	4.0	G
55	4.0	G
65	4.2	G

215605
V Pegasi

J.D. 242	Est.	Obs.
1161.5	12.1	Ba

215934
RT Pegasi

J.D. 242	Est.	Obs.
1140.6	<11.3	V
59.5	<11.3	V
61.5	10.9	Ba

220412
T Pegasi

J.D. 242	Est.	Obs.
1139.6	13.6	B
61.5	<13.2	Ba

220613
Y Pegasi

J.D. 242	Est.	Obs.
1139.5	11.2	O
39.6	11.1	B
40.6	11.5	V
58.7	12.7	Pi
59.5	<10.9	V
61.5	12.3	Ba

220714
RS Pegasi

J.D. 242	Est.	Obs.
1139.6	12.4	B
40.6	<11.7	V
58.7	<12.5	Pi
59.5	<10.9	V
61.5	12.6	Ba

VARIABLE STAR OBSERVATIONS October-November, 1916—Continued.

221321 X Aquarii

J.D. 242	Est.	Obs.
1162.8	7.9	Ho

221722 RT Aquarii

J.D. 242	Est.	Obs.
1162.8	9.8	Ho

222439 S Lacertae

J.D. 242	Est.	Obs.
1138.6	<12.7	Ba
61.6	12.0	Ba

223841 R Lacertae

J.D. 242	Est.	Obs.
1153.7	8.9	M

225120 S Aquarii

J.D. 242	Est.	Obs.
1151.5	9.6	B
53.7	9.2	M
61.5	10.0	Ba
61.6	10.0	Pi
61.6	10.1	WPi
62.8	10.1	Ho

225657 Delta Cephei

J.D. 242	Est.	Obs.
1154	4.1	G
55	4.1	G

225914 RW Pegasi

J.D. 242	Est.	Obs.
1104.7	10.6	R
38.6	11.1	Ba
39.7	10.6	Mu
40.6	11.5	V
51.6	12.0	Bu
54.6	11.6	M
58.5	12.7	B
58.7	12.3	Pi
59.6	10.7	Mu
61.5	12.9	Ba
64.7	13.0	Sp
65	10.4	G
65.7	10.7	Mu

230110 R Pegasi

J.D. 242	Est.	Obs.
1139.7	<11.2	Mu
58.7	12.0	Pi
61.6	11.5	Ba
63.6	11.9	Nt
67.6	10.5	M

230759 V Cassiop.

J.D. 242	Est.	Obs.
1105.0	10.0	R
38.6	1.24	Ba
58.6	12.5	B
61.6	12.2	Ba
63.6	12.5	Pi
67.6	12.0	M

231425 W Pegasi

J.D. 242	Est.	Obs.
1105.7	10.2	R
38.6	11.3	Ba
40.6	10.9	V
54.6	12.0	M
59.6	<11.4	V
61.6	12.4	Ba

231508 S Pegasi

J.D. 242	Est.	Obs.
1105.7	<10.7	R
54.6	12.6	Nt
61.6	13.0	Ba

233335 ST Androm.

J.D. 242	Est.	Obs.
1105.7	8.9	R
38.6	9.3	Ba
42.6	10.0	M
44.5	10.0	B
44.6	10.4	Bu
51.6	10.6	Bu
54.6	9.6	Hu
56.6	10.5	R
61.6	10.2	Ba
64.6	10.6	Pi

233815 R Aquarii

J.D. 242	Est.	Obs.
1130.4	6.5	L
38.3	7.0	L
38.6	6.2	Ba
51.6	6.8	Bu
56.6	7.1	R
61.6	7.0	Ba
61.6	7.4	Pi
61.6	7.8	Wpi
62.8	7.2	Ho
63.6	7.0	Hu

233956 Z Cassiop.

J.D. 242	Est.	Obs.
1150.6	12.0	M
54.6	12.2	Nt
61.6	12.4	Ba
63.6	12.4	Pi

235209 V Ceti

J.D. 242	Est.	Obs.
1138.6	11.3	Ba
53.7	11.0	M
61.6	12.5	Ba
63.6	12.7	Nt

235350 R Cassiop.

J.D. 242	Est.	Obs.
1138	<11.5	T
44.5	12.0	B
44.6	12.5	Bu
54.6	12.3	Nt
61.6	12.0	Ba

235525 Z Pegasi

J.D. 242	Est.	Obs.
1138.6	10.8	Ba
39.5	10.5	O
51.5	10.5	O
54.5	10.4	O
54.6	10.3	M
58.7	10.4	Pi
59.6	10.1	V
61.6	9.8	Ba
70.5	9.8	O

235939 SV Androm.

J.D. 242	Est.	Obs.
1138.6	12.4	Ba
42.6	<11.6	M
61.6	<12.7	Ba
64.6	<12.3	Pi

No. of observations 1544; No. of stars observed 242; No. of observers 28.

Mr. Bancroft calls attention to an error in the chart of the Variable *021403 o* Ceti (naked eye view) in the possession of many of our observers. A line drawn from the 4.5 magnitude star through the 4.0 magnitude star terminates at a star designated 4.9 magnitude on some charts. This star is η Eridani, a star of the 4.0 magnitude. Members who are using this defective chart are requested to correct this error.

The planet Neptune is now close to the field of the Variable 083019 U Cancri. Observers are notified of the fact to prevent needless disappointment in the announcement of a Nova.

The following calculated dates of maxima are cited from the "Companion to the Observatory."

Dec. 4	203847	V Cygni	Dec. 12	*151822*	RS Librae
5	163266	R Draconis	15	*233815*	R Aquarii
8	164055	S Draconis	28	210868	T Cephei
8	123307	R Virginis	30	230110	R Pegasi
11	180531	T Herculis	31	142584	X Camelop.

For the convenience of observers the following monthly Julian dates for the year 1917 are cited:

Jan. 0	2421229	May 0	2421349	Sept. 0	2421472
Feb. 0	1260	June 0	1380	Oct. 0	1502
Mar. 0	1288	July 0	1410	Nov. 0	1533
Apr. 0	1319	Aug. 0	1441	Dec. 0	1563

We are indebted to Mr. Wm. J. Delmhorst of Jersey City, N. J., for several observations contributed to this report which are designated by the abbreviation "De."

The Secretary regrets that owing to absence from home this winter he will have to give up his secretarial duties temporarily. During his absence Mr. John J. Crane, Shawme Farm, Sandwich, Mass., has kindly consented to act as Secretary, and lists due February 1st, March 1st, and April 1st should be sent to Mr. Crane. Acknowledgements of the receipt of lists will be dispensed with to lighten the work, and members can best assist Mr. Crane by sending in their lists promptly on the first day of the said months.

The following members contributed to this report: Messrs. Bancroft, Bouton, Burbeck, Crane, Eaton, Gray, Gregory, Hoge, Hunter, Lacchini, Leonard, Lindsley, McAteer, Mundt, Newberry, Nolte, Olcott, Phillips, D. B. Pickering, S. W. Pickering, Richter, Spinney, Vrooman, Whitehorn, Yendell, Miss Swartz, and Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Secretary.

Norwich, Conn., November 10, 1916.

SU Tauri.—A letter from Mr. H. C. Bancroft, Jr., of West Collingswood, N. J. calls attention to the decreasing light of the variable star SU Tauri, 054319. The variations of this star, like those of R Cor. Bor., 154428, are very irregular and peculiar. The variation is rapid, and has been confirmed here. The star should be watched carefully.

Harvard College Observatory, Bulletin 617,
Cambridge, Mass., U. S. A., November 17, 1916.

COMMUNICATIONS.

A Day of Exceptional Meteorological Interest.—The afternoon of July 2, 1916, was cloudy over the lower part of the Bay of Panamá and thereby developed a remarkable scene about half past five o'clock, as seen from the deck of the Pacific mail steamer San Juan.

Two great masses of cloud, dark leaden in hue, were in the west; and in them could occasionally be seen bright flashes of lightning running vertically. At the right—or north—of the middle of these clouds was a strip 3° to 4° wide, and 12° to 14° long, of sunshine on a white background; and at the summit of the northern cloud was a thin stripe of silver lining surmounted by a band of irregular shape on which were displayed broad spectrum effects; not arcs of rainbows, but rainbow colors in two or three broad masses. The phenomenon was a wonderful one and unique in my experience. It was visible for five or six minutes, gradually changing its shapes and finally shifting to the southern cloud, and disappearing through being covered up by the advance of a fresh mass of cloud.

That evening Polaris was visible at an altitude, by eye-measurement, of 7½°. By consulting a good atlas one may see how little this varied from the fact.

I made also an estimate of R Muscae, 68° south declination.

EDWARD GRAY.

A Rare Volume.—You and your readers may be interested to know that a gentleman and friend of mine residing in this city who makes frequent trips to New England was fortunate enough during a recent visit in Boston to locate and procure a copy of the first issued "Annals of the Astronomical Observatory of Harvard College," being Volume 1, part 1 and 2, published in 1856, which is now very scarce and difficult to obtain.

It is a "presentation copy" and on a blank leaf in front appear these words, evidently in the handwriting of Professor Wm. C. Bond, who was the first director of Harvard Observatory: "To Charles P. Curtis, Esq., from the Observatory of Harvard College. W. C. Bond, Director." Professor Bond was the father of the famous G. P. Bond who in 1850 discovered the faint third or inner ring of Saturn, commonly known as the "dusky ring." The volume is bound in brown cloth, and though somewhat worn from age it is complete and fairly well preserved considering the date of its publication.

On the title page is a wood cut of the original Observatory building, above which are these words: "Printed from funds resulting from the will of Josiah Quincy, Jun., who died in April, 1775, leaving a name inseparably connected with the history of the American Revolution." The volume contains a "History and Description of the Astronomical Observatory of Harvard College," by Professor Bond, the director, together with a number of diagrams and illustrations, and gives a great amount of information concerning the Observatory and its associates which is interesting to read and well worth preserving.

The volume contains a lengthy appendix with the reports of the President, Director and Visiting Committee of the Observatory, some of them dating back to the year 1845, and there are also a number of letters from American and foreign astronomers giving some valuable information pertaining to the heavens. Being the first annual publication issued by the Harvard Observatory it has long been out of print and is now an interesting relic of astronomical literature which would be a valuable addition to the library of any observatory or private student of the science.

The owner of the rare volume, not being specially interested in astronomy, offers it for sale, his price being seven dollars, which is very low for such a valuable treasure, and he has placed it in the hands of the writer who will send it post paid on receipt of the price.

ARTHUR K. BARTLETT.

Battle Creek, Mich., November 11, 1916.

GENERAL NOTES.

Dr. J. L. E. Dreyer has resigned his office as director of the Armagh Observatory, a position which he has held since 1882.

Maurycy Rudzki, director of the Cracow Observatory since 1902, has died at the age of 54 years.

Professor A. S. Donner, director of the Observatory of Helsingfors, has presented to the university of which he was formerly rector, the sum of £8,000, to ensure the continuance and completion of the "Catalogue photografique du Ciel, Zone de Helsingfors," begun under his direction in 1890. Hitherto the work has been paid for, partly by the university, partly by Professor Donner out of his private means. The sum now allotted by him is intended to cover all expenses for twelve years, when, at its present rate of progress, the task should be finished. *Science,* November 17, 1916.

Dr. Cleveland Abbe, the distinguished American meteorologist, died on October 28th, at his home in Washington, D. C., in the seventy-eighth year of his age.

Professor S. A. Mitchell, director of the Leander McCormick Observatory of the University of Virginia, has been appointed by Columbia University special Ernest Kempton Adams research fellow for a period of five years. This award comes as an extension of the regular Adams fellowship held by Professor Mitchell for the years 1914-16. The research undertaken was the determination of the parallaxes of the fixed stars by photography with the 26-inch McCormick refractor. Already the distances of one hundred stars have been determined.

Professor O. Backlund, director of the Pulkovo Observatory, died on August 29.

Dr. Percival Lowell, director and owner of the Lowell Observatory at Flagstaff, Arizona, died of apoplexy on November 12. He had during the previous month been on an extended lecture tour, giving astronomical lectures at the State College of Washington, University of Washington, Reed College, Oregon Agricultural College, University of Oregon, Leland Stanford Junior University and the University of California.

From the daily newspapers we learn that Dr. Lowell was buried on "Mars Hill" not far from the observatory in which he made so many of those wonderful drawings of the features seen on the surface of the planet Mars. According to the terms of his will the Lowell Observatory is to be supported out of a fund to be held in trust by William Lowell Putnam, the astronomer's brother-in-law.

The American Association of Variable Star Observers held its fourth annual meeting at the Harvard College Observatory on November 18, 1916.

Parallax of Barnard's Star with Large Proper Motion.—A letter received at this Observatory from Professor Frank Schlesinger, Director of the Allegheny Observatory, states that:—

"Measures of Photographs secured here with the Thaw Telescope yield a preliminary parallax of half a second of arc for the rapidly moving star in Ophiuchus, recently discovered by Barnard. The probable error of this result is about three one-hundredths of a second of arc." EDWARD C. PICKERING, Director.

Harvard College Observatory, Bulletin 616,
Cambridge, Mass., U. S. A., November 10, 1916.

Daylight Saving.—The plan of daylight saving in the summer time by setting the clocks forward an hour appears to have worked well in England. Even the astronomers have not seriously objected. Professor H. H. Turner in the October issue of *The Observatory* wrote in favor of the plan. Mr. C. Chree presents the other side of the question in the November number of the same journal.

Barnard's Star of Large Proper Motion.—A letter received at this Observatory from Professor Henry Norris Russell, Director of the Princeton University Observatory, contains the following preliminary values of the parallax of the star of large proper motion in Ophiuchus which have been determined by him from micrometric observations communicated by Professor Barnard.

From the differences of the distances of stars a and k, a solution in which the proper motion is eliminated in the usual manner, gives a parallax of $0''.69 \pm 0''.06$.

Measures of positives made from the plates of 1894 and 1904, when compared with the measures of 1916, give a proper motion of $10''.38$ toward $355°.8$. Assuming

this proper motion, the distance measures of the stars a, c, and k give parallaxes of 0″.85, 0″.53 and 0″.66, and the measures of position angle a mean parallax of 0″.75. The mean of these determinations is 0″.70 ± 0″.05.

The absolute magnitude of this star on Kapteyn's scale is 13.6, and its real brightness is less than one three-thousandths that of the sun, making it the faintest star so far known.

Harvard College Observatory, Bulletin 617,
Cambridge, Mass., U. S. A., November 17, 1916.

Professor Keeler's Photographs of Nebulae.—A limited number of copies of Volume VIII, Publications of the Lick Observatory (Professor Keeler's photographs of nebulae and clusters made with the Crossley reflecting telescope), are available for distribution to astronomers, students of astronomy, observatories, university and college libraries, and other libraries of high character, upon payment of the mailing charges. The volume wrapped for mailing weighs five pounds and will cost sixty cents to send to points east of Chicago, to Canada, and to such foreign countries as have parcel post interchange with the United States. The rates for points west of Chicago may be ascertained from the local postmaster. Money order or stamps for transportation charges should accompany the request.

W. W. Campbell.
Director Lick Observatory.

False Stereoscopic Effects.—It seems to be necessary to accept with caution the evidences of motion of stars based upon the stereoscopic comparison of two photographs. The following is taken from the notes "From an Oxford Notebook" in *The Observatory* for November, 1916:

"In turning over these pages of the *C. R.*, one's attention is naturally caught by the claims of M. Comas Sola to have found conspicuous proper-motions by the stereoscopic method (*C. R.*, 1915 Aug. 9) near M 11. Professor Barnard took the pains to examine the region on two plates having an interval of 22 years (*C. R.*, 1915 Oct. 4), whereas M. Sola's plates had only three years' interval; but could find no evidence of large proper-motions, a negative conclusion for which he was prepared by much previous work with micrometers both visual and photographic. But M. Sola was not convinced of any illusion or mistake, for a few months later he announces very sensible proper-motions, indicating a rotation, in the Orion nebula (1916 March 20). Now many of us have had experience of false stereoscopic effects: for instance, Dr. Metcalf, when studying theology at Oxford a dozen years ago, used our stereo-comparator, in his 'leisure' moments, with some diligence, and ultimately found a star showing a distinct stereoscopic effect which we all verified on his announcement. We proceeded to *measure* the two images with respect to surrounding stars, and could find no sensible difference! It was a considerable disappointment, but an educational one. There was no doubt about the stereoscopic effect, nor any obvious explanation of it except the usual one, but the usual one was negatived by the micrometer. It seems probable that if M. Sola would submit his plates to the test of measurement, he would also find the stereoscopic effect to be due to some obscure cause, and not to a sensible displacement."

The Eclipsing Binary RX Herculis.—In the Laws Observatory Bulletin No. 25 is given an extensive study, by Robert H. Baker and Edith E. Cummings, of the observations of the variable star RX Herculis ($\alpha = 18^h\ 26^m.0$, $\delta = +12°\ 32'$). This star is of the Algol type and its light changes may therefore be explained as

the result of successive eclipses of one by the other of a pair of stars which whirl around each other in a period of 1.78 days. The star is not double visually, but its spectrum at the proper times has double lines, so that there is no question as to its duplicity. The range of brightness is from magnitude 7.2 to magnitude 7.9. Figure 1 shows a comparison of the theoretical light curve

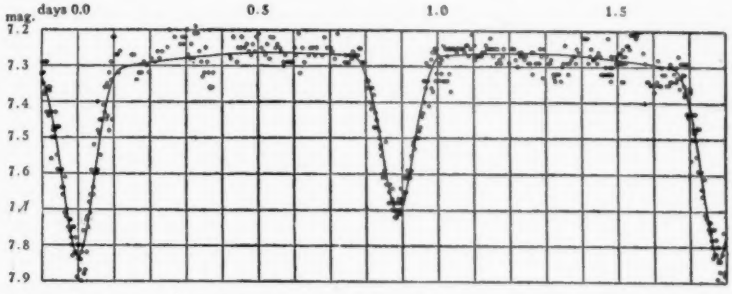

FIGURE 1. OBSERVED MAGNITUDES AND THEORETICAL LIGHT CURVE OF RX HERCULIS

with observed magnitudes. The secondary minimum is not quite so deep as the primary, showing that the stars are unequal in brightness. The calculations show, however, that the two stars have very nearly the same diameter, 1.6 times the diameter of the sun. The mass of the brighter component is 0.96 and of the fainter component 0.91 that of the sun. Their densities are respectively 0.27 and 0.23 that of the sun or about one-sixteenth the density of water.

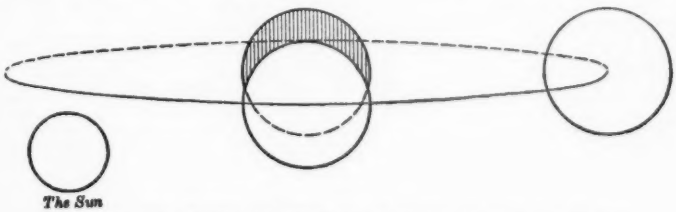

FIGURE 2. THE SYSTEM OF RX HERCULIS COMPARED WITH THE SUN, AT SECONDARY MINIMUM AND AT GREATEST ELONGATION.

Figure 2 gives the relative sizes of the stars and the sun and the aspects which they would present to us if we could see the actual stars when at conjunction and when widest apart. The orbits of the two stars are circular and their inclination (from perpendicular to the line of sight) is 83°.9. The distance between the centers of the two stars is about five times the radius of either star, or 5,280,000 kilometers. At conjunction 70 per cent of the disk of one star is eclipsed by the other. The semi-duration of eclipse is $2^h\ 53^m$.

The range of radial velocity indicated by the spectrograms is over 200 kilometers per second. When the brighter component is approaching us the velocity is about −124 kilometers, and when receding, about + 84 kilometers. The fainter component has a slightly greater range of velocity. The center of gravity of the two is approaching us, the radial velocity of the system being − 19.5 kilometers.

The Velocity of Vega.—A correspondent sends us a clipping from "The Pathfinder" of August 19, 1916, in which is given the statement that "Vega is leaving us at the rate of some 9,000,000 miles a second, according to the revelations of the spectroscope." The writer evidently made a big mistake in his calculations. According to the Lick Observatory measures the radial velocity of Vega is —13.8 kilometers or —8.6 miles per second, i.e. it is approaching us (instead of leaving us) at the rate of a little less than nine miles each second. As, however, the solar system is going toward Vega about 12 miles per second, the star is really moving in the opposite direction between three and four miles a second. Vega also has a cross-motion of approximately seven miles a second, so that its real motion through space is very near eight miles a second. It would take Vega nearly two weeks to move 9,000,000 miles.

Ancient Astronomy in Egypt.—A pamphlet recently issued by "School of Antiquity", Point Loma, California, entitled "Ancient Astronomy in Egypt and its Significance", by Frederick J. Dick, professor of mathematics and astronomy, contains some very remarkable statements,—very important if they can be verified. For example:—

"The Assyrians have not only preserved the memorials of seven and twenty myriads (270,000) of years, as Hipparchus says they have, but likewise of the whole planetary sidereal periods and periods of the seven rulers of the world."

"The Hindus are said, on pretty good authority, to have had the complete records of thirty-three precessional circuits, this amounting to over 850,000 years."

"The Egyptians have on their zodiacs irrefutable proofs of records having embraced about 87,000 years."

"Pomponius Mela wrote that the Egyptians preserved in written records the memory of the fact that the stars had completed four revolutions, or more than 100,000 years, during their history. Pliny wrote that Epigenes assigned 720,000 years to the astronomical observations of the Chaldeans."

This is going a great deal farther back than students of the early history of astronomy have hitherto dared to suggest as possible.

The American Astronomical Society will hold its twentieth meeting in connection with the seventieth meeting of the American Association for the Advancement of Science in New York City from December 26 to December 30, 1916. This is the first of the greater quadrennial meetings of the A. A. A. S., and an effort is being made to have all of the affiliated societies in attendance. The address of the retiring president of the A. A. A. S., Professor W. W. Campbell, will be of special interest to the members of the American Astronomical Society. The Manhattan hotel, Forty-second and Madison streets, has been selected as headquarters for the American Astronomical Society. The session for the presentation of papers will be held in Room 304, Fayerweather Hall, Columbia University. The detailed program for the meetings of the Society has not yet been announced. It is planned to arrange the meetings of the Society at such times as to avoid conflicts with the general meetings of the Association. Sessions for papers will probably be held at ten o'clock on Wednesday, Thursday and Friday mornings and on Friday afternoon. On Thursday afternoon there will be a joint session of the Society with The American Mathematical Society, The Mathematical Association of America and Section A of the Association. The features of this meeting will be addresses by Professor E. W. Brown, retiring president of The Mathematical Society, and by Professor A. O. Leuschner, retiring vice-president of Section A. A large attendance is expected.